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NOTES AND COMMENTS.

The Influence of Non-Metallic Inclusions in Steel.

The influence on non-metallic inclusions in locating the deposition of ferrite from the γ solid solution, was first suggested by Brearley, in 1909. The subject was further enlarged by the Russian Metallurgist Ziegler, Dr. Stead carried out a large number of experiments with a view to determining whether or not non-metallic inclusions in steel induce ferrite to crystallise round them. The results of some of their experiments were summarised in a Paper given before the Iron and Steel Institute, in 1918. Broadly, the method adopted by Dr. Stead was to introduce various materials, including slag, manganese, sulphide, scale, quartz and other materials into holes drilled in small bars of known composition. The materials were pressed into the holes which were afterwards closed by steel plugs hammered and welded in. The bars were then heated to a temperature well within the γ solid solution range for a long time and allowed to cool slowly. After this treatment the bars were sectioned through the artificially introduced inclusion and examined under the microscope.

As a result of his experiments Stead was forced to the conclusion "that non-metallic inclusions . . . do not lead ferrite in steel to crystallise round them, and that it is the phosphorus which leads to the formation of the ferrite ghost line." In spite of this conclusion Dr. Stead was forced to admit that Mr. Brearley had found ferrite to deposit round sand artificially incorporated in steel, and was unable to suggest any reason why this was so in one case and not in others.

In spite of the negative results of Dr. Stead, it is very difficult for metallographers not to believe the original conclusions of Brearley and Ziegler, and the whole subject is not yet thoroughly cleared up.

Further investigations by two American workers, Messrs. Mahin and Hartwig, were summarised in a recent paper before the American Chemical Society. These investigators consider that the views of Dr. Stead may be incorrect. A summary of the conclusions drawn from their experiments is as follows:—

A considerable number of alloys and special steels have been turned into small rods and driven into holes in carbon steels, the whole assembled specimen then being heated to temperatures above the transformation range for the steel. The section of the slowly cooled piece then shows, in nearly all cases, ferrite segregation around the insert. The hypothesis that has been advanced to explain this phenomenon is to the effect that the special element, elements, or compounds have diffused into the surrounding steel, and that they have there exerted an influence toward throwing ferrite out of the austenitic solution when the latter cools into the transformation range.

These experiments are cited as possibly throwing some light upon the character of the influence of non-metallic inclusions upon ferrite segregation. The inclusion must have a certain slight solubility in austenite, and the concentration of the dissolved matter is therefore greatest in the immediate vicinity of the inclusion. There must also be equilibrium products of reactions occurring between the material of the inclusion and the steel. These products also must have a slight solubility, and they also are localised about the inclusion. Such a condition of localised dissolved impurities might have the effect of starting ferrite crystallisation first about the inclusion, thus breaking down the state of ferrite supersaturation that always occurs in hypoeutectoid steels between the temperatures Ac_1 and Ar_1.

If these hypotheses are correct, it is easy to see the importance of uniform distribution of all elements of carbon steel, as well as of alloy steels, as otherwise it is not possible to have uniform carbon distribution, and the finished piece cannot be brought into its best condition by any ordinary heat treatment.

This latter conclusion confirms the view expressed by Brearley in the discussion on Dr. Stead's paper that no amount of heat treatment will remove the ferrite ghost lines from large steel forgings.

The British Cast-Iron Research Association.

The Council of the Research Association for the Iron foundry industry have decided to alter the name of the Association to the above title. The old title being considered to be too complex, and the new one will allow work to be carried out on more broader lines. The articles of association are now being considered by the Board of Trade, and it is expected that the licence will be granted at an early date, and the work of the Association will then be commenced. Already the Council have received very gratifying evidence that the industry will not only support the Association financially, but is ready to send into the research department problems for investigation. There has already been sent in to the Association a proposition which, if it can be solved, will somewhat revolutionise the manufacture of certain plants now carried out by ironfounders. The Council after considerable consideration have decided to levy the subscription upon the number of employees actually engaged in the foundry. The rates have been fixed as low as possible so as to induce even the smallest foundry to become members. A wise decision has been arrived at whereby the research work will be carried out in existing laboratories, as that for instance, a case for investigation from South Wales will be carried out in that district, enabling the local conditions to be thoroughly considered. Arrangements have been made for holding meetings of the various foundry employers' associations to discuss the work and objects of the Association.

The Provisional Council has now been completed, and the Government Research Department have nominated Sir W. T. Jones, Sir Robert A. Hadfield and Professor C. H. Desch as their representatives on such Council.

XUM

IMPORTANT ANNOUNCEMENT TO FOUNDRYMEN.

FIFTY GUINEAS IN PRIZES FOR BEST DESIGN AND EQUIPMENT OF A FOUNDRY.

To mark the change over of the FOUNDRY TRADE JOURNAL from a Monthly to a Weekly publication, the Proprietors have pleasure in announcing that they are offering two Prizes of Thirty and Twenty Guineas respectively for an article dealing with the subject of the design and equipment of a Foundry (ferrous or non-ferrous), with special reference to the latest labour-saving devices and machines, internal transport and handling tackle.

Competitors, by submitting articles, signify that they adhere to the following rules :—

(1) Competitors must be in the employ of an established British foundry subscribing to the FOUNDRY TRADE JOURNAL, or himself a subscriber.

(2) Articles must be illustrated with dimensioned drawings and sketches.

(3) The copyright of all papers and designs accepted for publication will become the property of the Proprietors of the FOUNDRY TRADE JOURNAL.

All papers must reach this office by Thursday, March 3rd, 1921. The decision of the Editor will in all cases be final.

Processes for the Production of Small Steel Castings.

The commencing of a foundry for the production of small steel castings presents many difficulties since there are so many different factors to be taken into consideration. The most important of these factors is undoubtedly the character of the process to be used in the production of the molten steel. Electric furnaces, owing to the fact that they produce steel free from gases and at a high temperature, seem well suited to run very thin and light castings. Especially so if the steel is shanked directly from the furnace spout to the moulds. Furnaces of small capacity, say about 1 ton, are probably the most suitable. In the crucible process, the earliest process used for the production of small steel castings, the pots are usually about 90 lbs. capacity—larger pots have generally been abandoned. The steel can be obtained exceeding hot and fluid and also free from gas, and, if proper selection of raw metals is made, the resultant steel is equally as free from impurities as electric steel. The steel is kept fluid in a hot pot longer than in a shank, and very thin section castings present no difficulty. The pot is quickly brought to the mould and poured.

A very small electric furnace would be necessary to shank the whole contents economically with the furnace at its highest temperature. To transfer the whole charge to one large ladle and from there to shanks would not be so satisfactory owing to the steel chilling. To cast direct from a large ladle would be cumbersome for small castings, and the steel would tend to set before the whole charge was cast.

The small electric furnaces cost more per ton of molten metal than larger ones—the cost increasing in inverse ratio to the size. Several small electric furnaces, say of one ton capacity, would be necessary to obtain a large output of exclusively small castings, and would be more expensive than, say, a single 10-ton furnace. In the crucible process the weight of metal per pot is standard and the problem of cost is not raised by the size and style of the process. The cost is, of course, reduced with a larger number of melts and is adapted for a very small output or a tonnage of any capacity only controlled by the number of holes. A comparison of the two methods may result in favour of the crucible—on the other hand, there are particular cases where the electric furnace has the advantage.

The Bessemer Converter process of 1- to 2-ton capacity also has advocates, and especially the side-blown converter. They claim many advantages over the two previous processes for the production of small steel castings. The total tonnage may be kept down to one ton, and the temperature may be made very high if necessary with the addition of high-grade silicon after already obtaining the initial heat from the original charged material. The number of heats is only limited to the floor capacity. Small converters, compared with similar capacity electric furnaces, could deliver over five times the tonnage in an equal time. The success of the converter process primarily depends upon the operator. A skilled blower can be relied upon to put charge after charge into the foundry, and well up to scheduled time. With low sulphur and phosphorus in the charged materials these objectionable elements need not be high enough to influence the quality unduly. The abnormally low sulphur and phosphorus which can be obtained at a cost with the electric furnace is not sufficient reason to condemn on comparison the blown steel. A casting with, say, 0.05 per cent. sulphur and phosphorus would compare equally with an electric casting, with the only difference of from 0.01 to 0.015 per cent. sulphur and phosphorus—other elements and heat-treatment being correct. Six single-ton heats from the electric furnace would cost considerably more than a similar tonnage from the converter. It is very doubtful if purchasers will willingly pay extra for the sole reason of lower sulphur and phosphorus, neither does the electric furnace hold the market for infallibly good castings.

The usual bottom-blown Bessemer and side-blown converter produce similar qualities. Generally the side-blown would produce the more fluid steel for small work, but the refining losses are from 5 to 10 per cent. greater than the bottom-blown converters. It is generally supposed that steel made by the "Blown" process absorbs unlimited quantities of oxides. This may happen in over-blown charges, which, however, are very rare when the furnaces are operated with skilled men.

The usual open-hearth furnace is not so successful for small castings. The extremely high temperature required cannot be obtained consistently without destroying the refractories and generally shortening the life of the furnace. The most successful type of open-hearth furnace for small work is the Siemens special rapid. This is usually of about 1 ton capacity. The producers are built on to the end of the furnace—the flame describing a horse-shoe bend before passing back through the same end on the way to the regenerators. The mixture usually charged for a 1-ton heat would be as follows :—Hematite, 4 cwt.; foundry scrap, 5 cwt. (runners and headers), and soft plate scrap, 11 cwt. The whole of the charge is rapidly melted until the bath is fluid. Samples for carbon estimation may be taken, but it is usual to adjust the amount of hematite to give the approximate carbon without any serious attempt to correctly refine the charge. The ferro-silicon and manganese are allowed to melt on the banks and run down into the bath. The carbon is somewhat high—from 0.60 per cent. to 0.80 per cent., and occasionally up to 1 per cent. The steel is shanked directly from the furnace and piled under the spout, the shanks, which hold about 1½ cwt. each, are piled under the furnace spout. The furnace is tapped—great care being taken to keep the tap-hole and the flow of metal not too large. The shanks are lifted away as they fill, the steel running into the one underneath. The tap-hole is stopped with a hard, dry cone of ordinary foundry floor sand, mixed with plumbago and coal dust, which is hand-rammed in a metal core box. The cores fit into a recess on the end of the stopping rod. The furnace tap-hole may be opened and closed many times in the course of a heat, the steel being kept hot in furnace in the meantime. The refining losses are small, but high carbon content rather condemns this process for many classes of small castings. This type of furnace, however, has been used extensively with great success for the production of colliery castings. The steel with low carbon is too sluggish and cold for casting small work, but with the addition of manganese excellent manganese steel can be obtained.

The basic Bessemer and basic open-hearth furnaces are not a success for the production of small castings.

It has been clearly proved that the old method of crucible steel-making can still more than hold its position against modern methods, and there are large buyers of small castings who have tried all processes, but eventually return to their former founders—the crucible steel-maker. There are authorities who still deny the superiority of electric steel. The quality of crucible steel may be due to the protection of the molten steel from oxidising gases, which are usually exhausted by charcoal addition, and also the protection afforded the metal of slag, which may be in contact with a neutral atmosphere.

Generally speaking, the very costly and expensively operated plants will not ensure any higher price for their products on the recommendation of slightly lower sulphur and phosphorus. The specialist can obtain high prices, but steel founders are not all specialists, but have to consider their various inquiries carefully in view of their own risks and their competitors' prices. The expense of the steel process in operation being the basis of the production cost, it would more than repay the very careful investigation when selecting the least costly and satisfactory process for the production of steel castings.

Suggested Labour-Saving Devices in a Foundry.

EDWIN A. HUNGER describes, in a recent issue of "The Iron Age," the labour-saving devices to be embodied in the new foundry which the Lycoming Motors Corporation, Williamsport, Pa., maker of automobile engines, is building to replace its present foundry. Wherever possible conveyors of various types will be used and efficient routing of work will receive special attention to reduce hand working to a minimum. In fact, it is figured that with the new foundry three times as much work will be possible with the same number of foundrymen as now employed.

The new foundry is being built on a tract of land of 15 acres, four of which will be under roof. It will be designed to turn out castings for 1,200 complete automobile motors a day, for which there will be a daily melt of 250 to 300 tons. There will be four cupolas with provision for two additional units to take care of future expansion. The big foundry is to be of all steel and glass construction, and a total of 1,800 tons of steel will be used in its erection. This steel is being furnished by the American Bridge Company, which is also erecting the steel part of the plant. The foundations and sand bins are to be of reinforced concrete. Division walls and wing walls 6 ft. high around the building are to be of stuccoed terra-cotta hollow tile.

The site for the new plant was selected both for railroad advantages and for future expansion. The main building will be 560 ft. long and 240 ft. wide, exclusive of a 30-ft. extension at the southern side where concrete bins for storage of core sand will be built. The superstructure of the building will be supported by trusses. The roof will be of the monitor and the ventilation system of the Pond operating type. The pattern shops, millwright department, laboratory, hospital locker and wash rooms and general offices will be at the west end of the main building, occupying a space 60 × 240 ft. Directly east of this space will be the charging floor. The cupola and coke and pig-iron storage areas will cover a section, 60 × 150 ft., which will be 60 ft. high, this height being necessary because of the space required for the overhead coke and storage bunkers and overhead monorail employed to supply the pig and scrap iron to the charging floor and core sand to the mixing room and bins. The charging floor will be 18 ft. above the foundry floor level, and will extend the full width and length of the area mentioned.

No opportunity has been neglected in the design of the new foundry to include belt conveyors, electrically-operated trucks and overhead trolley systems wherever possible, for the movement of the materials in place of hand operation. Efficient routing of the materials, both raw and semi-finished, will depend on these special conveyances, which will be so worked into the general plan of operation that there will be a quick and orderly process working from west to east, that is, from the cupola end on through to the shipping platform at the opposite or east end. Siding facilities for railroad cars will be provided for the unloading of raw materials and the shipping by railroad of the finished engines (so far as foundry work is concerned) to the company's machine shop, which will be on the other side of town where the present plant now is located. Three railroad spurs will run along the north side and two of these will be on a 2 per cent. grade to allow the moving of cars by gravity. The grade will be long enough for three cars to be thus moved on each track. Another side track will run along the south side of the foundry.

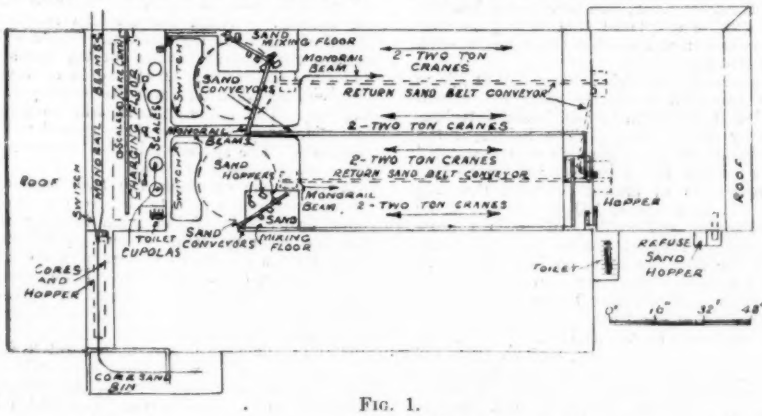


FIG. 1.

The inside track on the north side will run over a track hopper into which coke will be dumped. A Rexall conveyor belt will carry the coke to belt bucket conveyors, which in turn will carry it up and deliver to another Rexall conveyor belt that will distribute it evenly by means of a movable hand-operated tripper into coke bunkers of 600 tons capacity above the charging platform. Eight hopper gates and chutes will be provided in the bottom of the bunkers for delivering the coke on the charging floor directly in front of the cupolas. The coke will be dropped into wooden baskets of 100 lb. capacity for exact measurement of coke which will be emptied by hand into the cupolas.

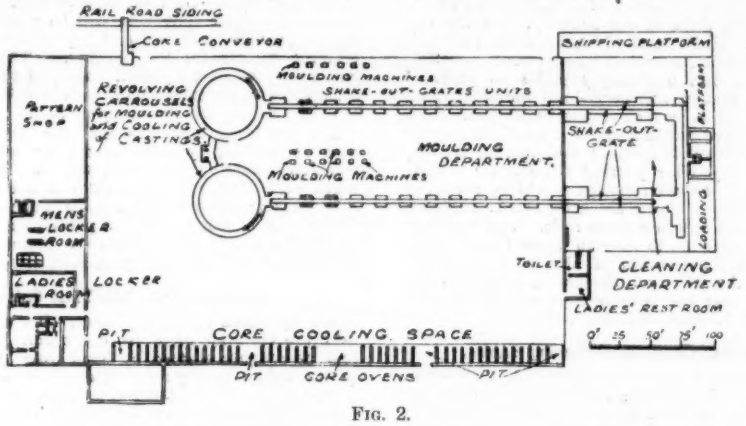


FIG. 2.

Pig and scrap iron will be unloaded from cars on the middle north siding (which will run under a big A frame) by means of a 1-ton 52-in. Cutler-Hammer magnet and then conveyed to any one of 25 bins provided for storage purposes on the loading platform by a 5-ton cab-operated monorail hoist. These bins will have a capacity of 2,700 tons, sufficient for a two weeks' supply. Provision will also be made for storing outside in the yard 5,000 tons of pig-iron and also surplus sand and coke. This extra material will be moved by means of a 30-ton locomotive crane with 50-ft. boom which will run around the plant on the north, east, and south sides.

The pig and scrap iron will be taken from the bins on the charging floor to conveniently located scales, where the charges will be weighed and then hauled to

the cupolas by electric elevating platform trucks. The iron will be thrown in by hand in order to get as even a charge as possible. Mechanically operated charges have been considered, but the Lycoming Motors Corporation has found that for the type of high grade grey-iron castings required in automobile-motor construction better results can be obtained by hand charging.

As already noted there will be four cupolas with provisions for two additional units. Two of these will be 96 in. in dia. and two 84 in. Their overall height will be 68 ft. The cupolas will be of the continuous melting Whiting type, with a special windbox and tuyere arrangement which will obviate the clogging of the tuyeres with molten iron or slag. They will be equipped with chain hoists for lifting the bottoms into place. Three No. 7 Roots blowers of the positive type (one blower is a reserve unit), each connected to a 50-h.p. General Electric motor, will be utilised, and the reserve blower will be so placed that it may be connected into either line from the other two blowers, each of which serves two cupolas.

Beyond the cupola area (which is 20 × 150 ft.) is to be located the extended moulding room which will occupy a space 150 ft. wide (to be subdivided into four moulding bays) by 380 ft. long. The height of the moulding department to the underside of trusses will be 21½ ft., this height being determined by heights necessary for operation of cranes. Beyond the big moulding room will be a space, 100 × 150 ft., to be devoted to the cleaning and welding of castings, sorting, inspection and packing of parts for shipment. Directly outside the cleaning room on both the north and east sides a shipping platform will be provided from which as many as five railroad cars, exclusive of trucks, may be loaded at one time.

An elaborate system of overhead trolleys will be installed in the main foundry room, and so arranged that the moulds for the larger castings may be poured on the two huge circular carousel conveying platforms already mentioned, or moulds for the smaller castings poured out on the floor beyond. Hand pouring thus will be reduced to a minimum. The trolley system will be equipped with a turntable arrangement consisting of four turntables so grouped as to permit the transverse movement of ladles; by means of this, molten iron can be moved to both sides of the foundry. On the long runs of the monorail lines, of which there will be two in each foundry section, there will be crossover sections located to allow full and empty ladles to pass. A separate trolley system will be utilised for pouring the metal into the moulds on each carousel conveyor. Eight 2-ton, hand-operated Shepard cranes with electric hoists equipped with controllers specially designed for foundry use will be employed for pouring the smaller moulds, which after being made on machines will be set up on the floor, and will be moved along the monorail system described above on separate crane rails. The monorails will be so arranged as to overlap these 2-ton cranes, thus permitting the removal of the ladles from the monorail with the hoist on the cranes and then distributing them over the pouring area as desired. Use will be made of 1,500-lb. Whiting ladles.

The Circular Continuous-Pouring Tables.

What may be easily classed as the outstanding feature of the new Lycoming Motors foundry will be the two large circular or carousel type conveyors already referred to several times in this article. The outside diameters of these circular conveyors or carousels will be 60 ft., and the platform or table, which will be 5 ft. wide, will be flush with the foundry floor. Each carousel will be driven by a 10-h.p. Electro-Dynamic motor through worm gear reducers, which will be connected by belt to the motor. By changing the size of the belt pulleys it will be possible to vary the peripheral speed of the table or carousel from 3½ to 5 ft. per min. Fifty-four minutes will be required for one complete revolution at a peripheral speed of 3½ ft. per min. The tables will be of steel plates supported on a steel channel frame, bent to conform to the diameters of the tables. They will rotate on steel rails mounted on a concrete foundation. The pit for the underconstruction will be 4½ ft. deep. The carousels and all conveyor equipment will be furnished by the Lamson Company, Boston, and are illustrated diagrammatically in Fig. 2.

These carousels, as already pointed out, will be used to make the larger castings, such as cylinders and crank cases, one carousel to be devoted exclusively to the making of each type. The north or outside carousel will thus be used for the crank cases or soft-iron castings. The entire moulding area, by the way, will be divided into two parts, one to be devoted to the making of soft castings and the other, or south half, to hard castings.

The moulding machines for the making of crank cases and cylinders will be placed along the outside of the carousels. Moulds will be placed on the carousel tables, and cores will be set in place and moulds made ready for pouring as they move around to the pouring station. The monorails will be so arranged that pouring will have to be done at a definitely predetermined point, and if the mould passes beyond this point it cannot be poured until it is conveyed completely round again. After the moulds are poured, sufficient time (about 20 minutes) will be taken to complete the revolution for cooling. When the castings reach a joint just ahead of the moulding machines, cranes will be used to remove the castings, shake out the flasks over grates, and place the castings on the apron conveyors on which they will be taken on down the foundry for subsequent working. The flasks in turn will be returned to the carousel, which will take them around to the moulding machines. The space inside the carousels will be used for storing cores and flasks.

Next to the carousels the two Lamson apron-type conveyors which will extend from the carousels 295 ft. down either side of the main foundry room and on into the cleaning room deserve particular mention. Soft castings will go down one of these conveyors and hard castings down the other. Each conveyor will be 4 ft. wide and move at a speed of 4 ft. per minute. Each will be operated by a 5-h.p. electro-dynamic motor in the cleaning room.

Underneath each conveyor in a pit 8 ft. 3 in. deep will be Rexall Sahara conveyor belts, which will return the sand to the cleaning room end, where it will be raised to an overhead screen from which it will drop into a 200-ton storage bin. This screening will cover

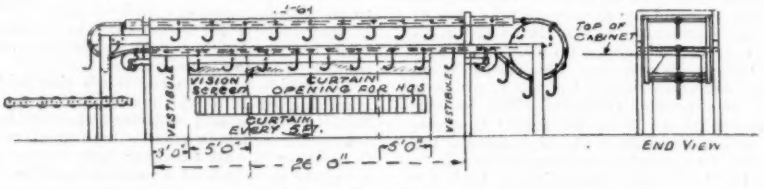


FIG. 3.

all the revivifying done to the used sand. After allowing sufficient time for cooling the sand will be returned by overhead belt conveyors going along the centre and north and south walls to hoppers over the moulding machines. These conveyors will be provided with the necessary deflectors, reshaping plows and automatic tripping devices for the hoppers. The storage bins will be replenished by sand conveyed by wheelbarrow from three large storage bins, each of 400 tons capacity, located just beyond the cleaning room.

The moulding machines for the smaller castings such as pistons, cylinder heads, fly wheels, exhaust manifolds, bearing caps, etc., will be placed along the north wall, along the centre columns and also along the columns separating the core room and moulding room. These moulds will be set and poured on the floor, and the flasks later shaken out over grates that will be placed over the sand conveying belts already mentioned.

Conveyor Type Sandblast Cabinet.

The cylinders and crank cases, after being delivered into the cleaning room by the apron conveyors, will first be roughly cleaned by hand over grates adjacent to the apron conveyors. The castings will then be picked up by hooks attached to a sort of endless ladder chain, which will convey the castings through each sandblast cabinet at the rate of 4 ft. per minute, and which will be operated by a 5 h.p. motor. An operator will easily be able to push a casting over to a hook and steer the hook into a hole or corner of a casting. Both ends of each cabinet where the castings enter and leave will be provided with swinging doors and curtains to prevent the escape of dust. Four operators will work from the outside of the cabinet and direct their sandblast nozzles through curtained openings in the side. Each operator will work upon a certain definite part of each casting to facilitate production. One of the cabinets will be used for the sandblasting of crank case castings and the other for cylinders. The used sandblast sand will be automatically removed by screw and bucket conveyors, and after being screened will be used again. An exhauster and dust arrestor, also to be furnished by the Mott company, will be used to remove the dust from these two cabinets; these will also serve other cleaning equipment in the cleaning room. This is illustrated in Fig. 3.

English and American Types of Electric Iron and Steel Furnaces Compared.

(*Continued from Page* 7.)

By John B. C. Kershaw, F.I.C.

The Greaves-Etchells Electric Furnace.

This furnace is an English design of the same type as the two previously described; that is to say, it is provided with vertical electrodes and a conducting hearth, and is operated with either two- or three-phase alternating current. This thermal effect, therefore, is produced by a combination of arc and resistance heating.

The furnace was fully described in a Paper read by Mr. H. Etchells before the Faraday Society in 1918. It was operated at Sheffield and at Rotherham during the war period for the production of special steels. Fig. 3 shows a 3-ton furnace of this type, installed at the plant of the Dodge Steel Company at Tacomy, Pa., U.S.A. This furnace is engaged upon the production of high-grade steel for castings, and was erected by the Electric Furnace Construction Company of Philadelphia. The special patented features of the Greaves-Etchells furnaces are the means taken to convert the unsymmetrical and consequently unbalanced currents of the secondary transformer system so that there may be a balanced load on the high-tension supply phases; and the advantages claimed by the inventors for this system of construction are the following :—

(1) The charge is rapidly melted and very uniformly heated, owing to the continuous circulation of the metal.

(2) The heat is generated both above and below the bath, and can be regulated over a wide range. No cold bottom is encountered.

(3) The hearth of the furnace is at least 20 in. thick, and a very safe container of molten steel. With reasonable care it will last over 1,000 heats.

(4) There are no water-cooled studs or embedded carbon electrodes in the hearth to conduct away energy.

(5) It is suitable for two-phase or three-phase current.

(6) If one arc be broken the other arcs are not affected.

(7) Sudden overloads are more effectively buffered without the use of external reactances than in any other type of furnace.

(8) The system allows an even temperature to be obtained throughout the whole of the furnace charge, and does not punish the roof and walls to the same extent as in furnaces in which the whole heat is generated over the bath.

(9) The energy consumed per ton of steel melted or refined is as low as, or lower than, that with any other type of furnace.

FIG. 3.—3-TON GREAVES-ETCHELLS ELECTRIC FURNACE AT THE DODGE STEEL COMPANY, TACOMY, PA., U.S.A., POURING INTO CRANE LADLE.

These advantages, with the exception of No. 4, are of course shared by the Booth-Hall and Girod types of furnace, and the special feature of the Greaves-Etchells furnace which gives it an advantage over the other two lies in the method by which the electrodes are connected with the separate terminals of the two secondary windings of the transformer, while the other terminals of each of these transformer windings unite in a star-point, with one terminal of a third transformer secondary winding. The outer terminal of this latter winding is connected to the furnace bottom and to earth respectively. These three transformer windings can be shown diagrammatically in Y form, and are grouped in what is generally known as the "star" arrangement. In an electric steel-melting furnace, however, it is impossible to make the resistance of the furnace hearth equal to that of the arc maintained by each electrode. As regards the transformer connected to the hearth, therefore, the symmetry of the star is unbalanced in the usual application to this system to electric furnace work, and external reactances which come into operation automatically have been employed to correct this defect.

In the Greaves-Etchells system, by reason of the particular arrangement of transformer secondary windings, any current traversing the path from one electrode to another, or through the furnace hearth, must pass through two transformer secondary windings in series. Since these secondary windings are each excited by primary windings of different phase relationship, the secondary current is in phase with neither. Being out of phase with both, the power factor of that particular secondary circuit is materially lowered, so that any excess of current due to a short-circuit on the electrode is checked and limited by the increasing reduction of the power-factor. Providing the currents are normal, the lagging power-factor of one side of the system is balanced by the leading power-factor of the other, so that the overall power-factor is very good.

The Greaves-Etchells type of furnace has been constructed in various sizes from ½ up to 12 tons capacity, and during the later stages of the war it was widely employed at Sheffield and Rotherham for working up the turnings and borings of the nickel-chromium steel supplied to the gun and shell factories. The smaller sizes of the furnace could melt and refine nine charges of scrap metal per day, and could be operated by two men and a boy, as compared with 15 men for a similar output or tonnage of crucible steel.

C

The Gronwall-Dixon Furnace.

This furnace is an American adaptation of the steel-refining furnace originally designed by the Swedish engineer, Grönwall, and known by his name. The furnace resembles the three already described, since it makes use of combined arc and resistance heating, and possesses two vertical electrodes and a conducting hearth. The furnace shown in Fig. 4 is only of half-ton capacity, but the special features are clearly distinguishable. The furnace shell is rectangular in shape, the carbon block which forms the lower terminal in the furnace hearth is fixed in an iron casting bolted to the furnace bottom, and does not project above the furnace lining of magnesite brick.

The special features of the electrode holders are that the contact is made low down on the graphite rods, and that the motors which operate the electrodes are mounted on brackets on the same supports. The holders are constructed of strong iron castings and T-irons, and the electrodes are water-cooled where they pass through the furnace crown.

The furnace is designed for operation with two-phase alternating current, the hearth being the neutral point of the electrical connections, and each electrode being connected to the terminal of one phase of the electric windings. In a valuable Paper read at the 31st meeting of the American Electrochemical Society held at Detroit, Mr. J. L. Dixon discussed some of the principles which should be observed in the design of electric furnaces for steel melting. He emphasised the advantages of some of the features of the Grönwall-Dixon type of furnace, especially that of the hearth electrode, both from the electrical and thermal point of view. The advantage claimed for the use of two-phase current is that it is more economically generated than single-phase, and that it is also more easily controlled, while the design of the furnace can be simplified as compared with that required for three-phase work.

The Heroult Furnace.

The Héroult arc-type of steel-melting and refining furnace is so well known, and has been so often described, that no detailed description is required here, and it will suffice to say that the essential difference from the four types already described and illustrated is that it possesses no bottom electrode, and the thermal effect therefore is produced entirely by *arc-heating*.

It is true that in the early method of work with the Héroult type of furnace the electrodes were allowed to dip into the slag, and in this way a certain amount of resistance heating was permitted, but in all the later installations of the furnace this plan has been discarded in favour of direct arc-heating. As forecasted by the author in his book published in 1913, the Héroult furnace is now generally employed with two- and three-phase current, and in its larger sizes is worked on what is called the duplex or triplex system; that is to say, it receives charges of molten metal from the Bessemer converter or open-hearth furnace for the final heating and refining operations, and for the addition of the alloy metals when special steels are being produced.

Fig. 5 represents a 5-ton Héroult furnace provided with three electrodes, for operation with three-phase current. The system of electrical connection employed is to have the three suspended electrodes connected to a star or delta group of transformers, with the molten bath as an unconnected starpoint.

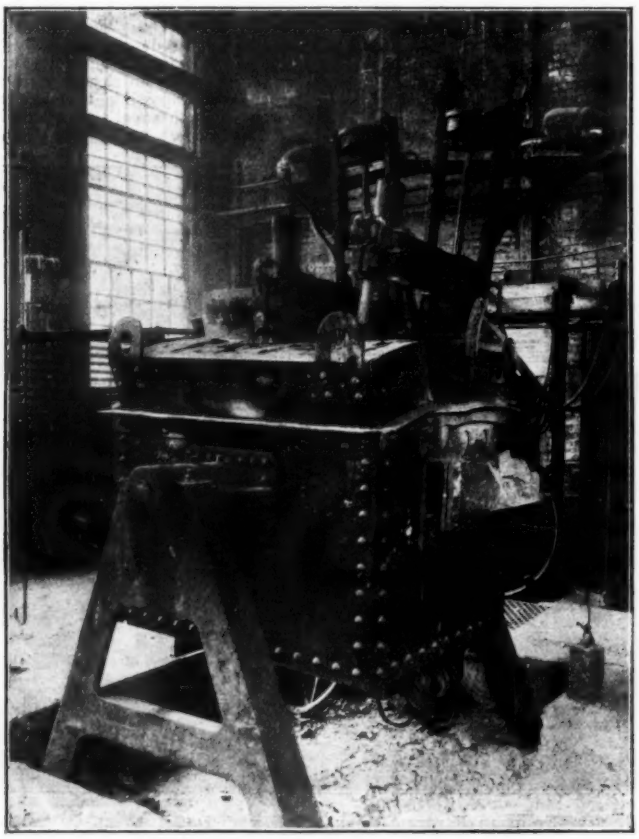


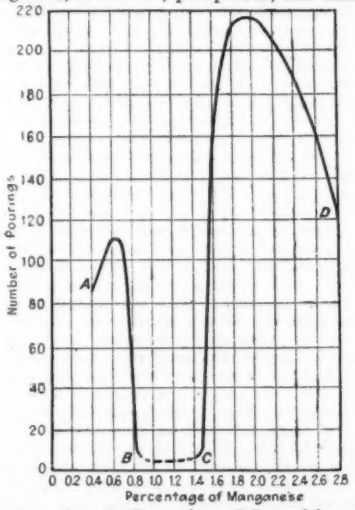
FIG. 4.—VIEW OF ½-TON GRONWALL-DIXON ELECTRIC FURNACE

NEW ETCHING REAGENT FOR IRON AND STEEL.—The "Iron Age" describes the experiments of H. S. Rawdon, of the American Bureau of Standards, on the use of ammonium persulphate as an etching reagent for iron and steel. This reagent is one of the most widely used for revealing the microstructure of certain non-ferrous alloys, and its use for revealing the microstructure of ferrous alloys has been previously suggested by Czochralski (Stahl und Eisen, No. 35, 1915). Its use as a reagent for revealing the microstructure of iron and steel appears to have largely been overlooked. A complete description of the principles underlying the action of ammonium persulphate and its method of application will be found in the original article. Illustrations of typical structures developed are also included.

ENGINEERING TRAINING ORGANISATION.—At a recent meeting of the Executive of the Engineering Training Organisation, the Engineering and the National Employers' Federation arranged to carry on this work. The Engineering Training Organisation has carried on for three years as an independent body without any paid staff, and from time to time the Executive issued memoranda dealing with different phases of engineering training, and finally compiled a Report, including a Register of available schemes of training which fills a volume of some 330 pages. This is not yet available to the public, but hope is entertained that it will be published in due course by the Engineering Employers' Federation.

Manganese in Ingot Moulds.

Steelworks and foundries commonly employ for casting of ingot moulds an iron analysing :—Silicon, 1.75 to 2.0; manganese, 0.4 to 0.6; phosphorus, less than 0.15; sulphur, less than 0.10; carbon, 3.5 to 4.0 per cent. Manganese is limited to 0.6 per cent. in the belief that with a higher percentage the moulds would crack after a limited number of pourings. Tests made by M. Grosclaude (and published in the French "Génie Civil"), covering a period of many years, have proved, however, that an increase of manganese on the contrary lengthens the life of the moulds. Thus, with ingot moulds of the above composition, the maximum number of pourings was 110, whereas as many as 250 were made with moulds of the following composition:—Silicon, 1.5 to 1.8; manganese, 1.75 to 2.25; phosphorus, less than 0.10; sulphur, less than 0.05; carbon, 3.25 to 3.50 per cent. The average obtained with moulds of this composition during two consecutive years was 175 pourings, with a minimum of 125. The results of the tests are plotted in the accompanying graph, by which it is seen that the manganese content has a great influence on the life of the mould. No tests have been made with analyses between the points



Catalogues Received.

We have received from Messrs. Automatic & Electric Furnaces, Ltd., 281-283, Gray's Inn Road, London, W.C.1, No. 26 Heat Treatment Bulletin, dealing with the subject of "The Heat Treatment of Mining Drills," by E. A. Wraight, A.R.S.M., M.I.M.M.

We have received from Messrs. E. C. Acheson, Limited, 40, Wood Street, London, S.W.1, a series of their publications, entitled, Acheson Electrodes in Use, Products of the Electric Furnace, Electric Furnaces, Brass Melting, etc. They contain much useful information for people interested in the subject of electro-metallurgy.

PAYMENT BY RESULTS.—The workers of Messrs. Lambourne & Company, Limited, engineers, of Openshaw, Manchester, have adopted a system of payment by results, originally introduced by their employees, and the first month's trial has given cause for general satisfaction. At a conference of the shop committee and management it was decided at the beginning of this month to fix a datum line of output above which the employees should earn a double bonus. The datum line was fixed for the average output in tons for the last six months, with safeguards as to number of employers and hours worked, and the total wages of the workmen are now made up as follows:—(1) Manchester district rate of wages, plus small weekly bonus on account; (2) bonus on total tonnage output up to datum line; (3) double bonus on output above datum line.

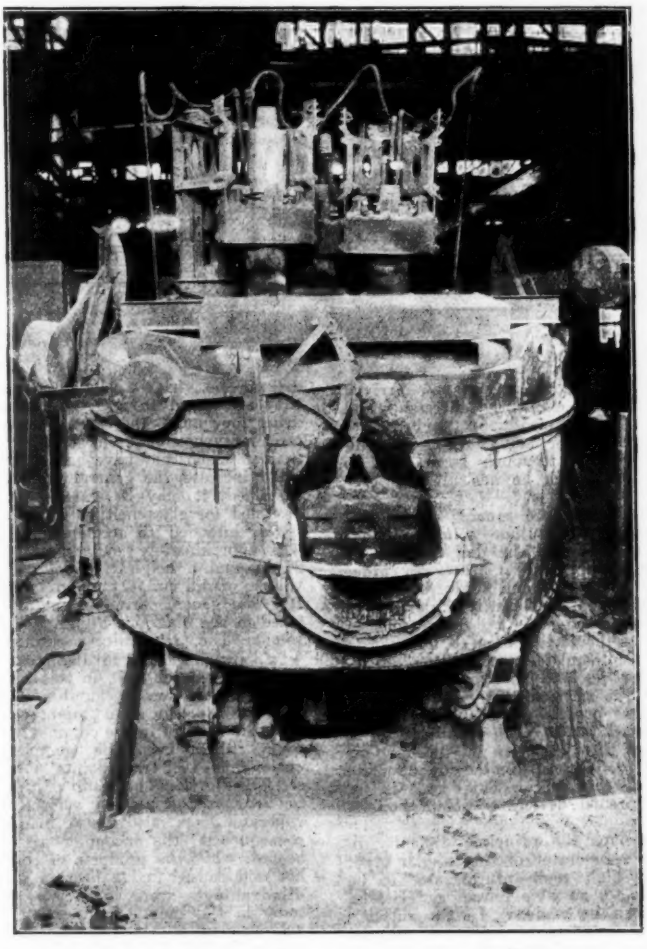


FIG. 5.—VIEW OF 5-TON HEROULT ELECTRIC FURNACE.

A New Type of Recuperative Furnace.*

In connection with the research work on glass and refractories carried on at the National Physical Laboratory, the necessity was early felt for a new type of experimental furnace suitable for glass meltings and for the firing and testing of refractories at very high temperatures, maintained for a considerable time. None of the available types of furnace appeared to meet the requirements of this work, particularly because it was regarded as essential that the furnace should be capable of running for long periods entirely without attention, so as to avoid the necessity for a "night shift" for experimental work. Among furnaces capable of melting down cones 28 to 30, or of attaining temperatures above 1,600 deg. C., there was only a very small choice. Most of these worked with an air blast derived from a fan or blower, and such a plant could not be left to run unattended over-night. It thus became evident that a gas or oil fired furnace, working with natural draught, was the only suitable type, and with a furnace of that kind the very high temperatures desired could only be attained by some method of pre-heating the air supply. The choice lay between the types generally known as "regenerative" and "recuperative." The regenerative type was at once ruled out on account of the necessity of reversing the valves at frequent (usually half-hourly) intervals, an operation which would require the presence of an attendant throughout the run. On the other hand, existing furnaces of the recuperative type, of which the well-known "Hermannsen" furnace is a good example, did not appear to be readily adaptable for use in small sizes, owing to the relatively large dimensions of the recuperator blocks and the thickness of the walls of the passages through which the interchange of heat takes place.

The author was accordingly led to design a special type of furnace for his work and, as a result of several successive modifications, he has now arrived at one which is not only eminently successful and satisfactory for his special purpose, but appears to lend itself to development for many other uses, including its adaptation both to much larger and to smaller sizes than those which he has hitherto constructed.

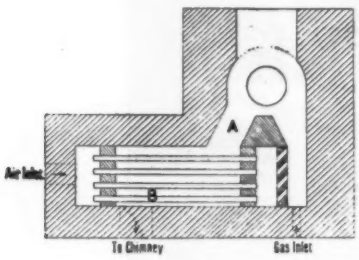


FIG. 1.

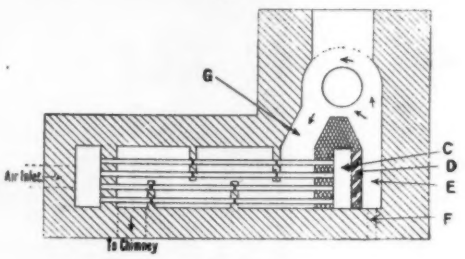


FIG. 2.

In seeking to design a furnace capable of yielding very high temperatures, the author considered that the principal factor must lie in the design and construction of the recuperator or pre-heater in order that the waste heat of the outgoing products of combustion should be transferred as efficiently as possible to the incoming air (since coal gas was, for reasons of convenience, adopted as the fuel to be used, preheating of the gas was not contemplated). The type of recuperator or preheater adopted therefore determined the entire design of the furnace. The only form of recuperator which gave promise of affording the desired efficiency appeared to be that consisting of a nest or battery of tubes through which the incoming air is drawn, while the products of combustion circulate about the exterior of the tubes. This type is, of course, well known in such devices as steam boilers, condensers, etc.

The initial and perhaps the principle difficulty in the construction of a recuperator of the tubular type, especially when very high temperatures are to be attained, lies in finding a suitable refractory material of which the tubes can be made. In the author's earlier experiments a considerable degree of reliance was placed upon the cooling effect of the incoming air, but experience very quickly proved that this did not suffice to protect tubes of insufficiently refractory material. Sets of tubes made of vitreous silica, of the best fireclay, and of "Salamander," rapidly failed in succession, either by breakage or "sagging." Fortunately the author's research work, dealing with "special" refractories, had already drawn his attention to the remarkable properties of bodies made of silicon carbide made up with varying amounts of china clay, or good fireclay serving as binder. Tubes made of this material have proved eminently satisfactory, and the initial difficulties of making the tubes have been overcome.

The composition of the tubes has varied somewhat, a larger percentage of clay being permissible in those tubes intended for use in the cooler parts of the recuperator than in those exposed to the products of combustion leaving the combustion space at the fult furnace temperature. For the latter position, where the tubes may attain a very high temperature (between 1,400 deg. C. and 1,500 deg. C.) a mixture containing about 20 per cent. of china clay and 80 per cent. of silicon carbide has been found quite satisfactory, although successful tubes have been made with china clay up to 40 per cent. The higher percentages of china clay only become desirable, however, if the tubes are to be made by a slip-casting process, for which purpose the 40 per cent. china clay mixture is very suitable. Care must, however, be taken to see that a china clay of the most refractory kind is used, and that it is not in any way contaminated with foreign fluxes of any sort, as a slight decrease in the viscosity of the binder at high temperatures allows the tubes gradually to sag and fail in service. For the tubes to be used at the colder end of the recuperator the proportion of silicon carbide may be progressively reduced. The tubes can be prepared by slip-casting, moulding or extrusion in any of the well-known ways; if the percentage of china clay is very low the "green" tubes are very fragile, but they become very strong and hard after firing. The tubes are fired up to a temperature of fully 1,500 deg. C.—i.e., a temperature higher than that at which they are to be used. This is important, because articles made of silicon carbide exhibit a great tendency to sag or deform—i.e., have a low viscosity—the first time that they are raised to a given temperature. During the firing they must, therefore, be carefully supported, and they must not be used at a higher temperature than that at which they have been initially fired.

To indicate the general size of the furnace to be described, it may be stated that in the first furnace designed for glass-melting experiments the combustion space, intended to accommodate one pot or crucible, was approximately cylindrical, with a diameter of 24 in. and a height (inside) of 18 in., with a total volume of 4.8 cu. ft. and an internal surface of 16 sq. ft. The general arrangement of this furnace is indicated in the diagram, Fig. 1, which shows a horizontal section. The recuperator contained fourteen tubes, each 4 ft. long and 1¼ in. in diameter.

It will be seen that in this furnace the tubes were comparatively few in number and of large diameter, while the products of combustion, passing outwards from the furnace to the chimney, took an uninterrupted course direct from the combustion chamber to the outlet flue—i.e., from points A to B in the horizontal section, Fig. 1. The result of this arrangement proved to be that the heating surface provided by the recuperator was altogether inadequate, and that, in consequence, the incoming air was not sufficiently heated, while the products of combustion remained too hot and caused undue heating in the chimney. These disadvantages were, to a considerable extent, overcome in the next modification of the furnace, the arrangement of which is indicated again in horizontal section in Fig. 2. The number of the tubes has been increased to 20 and the recuperator lengthened by 13 in., the diameter of the tubes remaining the same as before.

The course of the products of combustion through the recuperator, however, has now been controlled by the introduction of four baffles, forcing the gases to follow a zig-zag and, consequently, much larger path from the combustion chamber exit to the outlet flue. In this form the furnace gave very satisfactory service, temperatures of 1,550 deg. C., being obtained with ease in the melting chamber, and a large number

* From a lecture by Dr. Rosenhain before the Sheffield Gas Consumers' Association.

of experimental glass meltings have been carried out in it. The furnace could be allowed to run for many hours without any attention whatever, and, provided that the gas pressure and draught remained constant, a very steady temperature was maintained. After a little experience it was possible to set the controls in such a way that the furnace would attain within 50 degrees of the desired temperature in a desired time; such an adjustment could be made in the evening and the furnace found at the desired temperature in the morning.

The general arrangement of this furnace, apart from the recuperator—which has already been described in detail—will be readily understood from Fig. 2. It will be seen that the preheated air leaving the tubes passes into a collecting chamber (C), and is then directed by a series of baffles (D) into a mixing chamber (E). Here it meets the coal gas, which enters by three horizontal tubes or burners (F), the flame is developed in chamber (E) and in the space around the pot in the combustion chamber and passes out through the exit (G) into the recuperator.

This particular furnace was provided with an opening at the front, through which the pots could be inserted or removed, and a working opening in the roof for manipulating the glass or other contents of the pot.

In the subsequent development of the furnace further changes have been made in the same general direction. These have resulted in the construction now adopted, in which the recuperator tubes are much more numerous and of smaller diameter and of much smaller thickness of wall, while the system of causing the products of combustion to take a zigzag path by means of baffles has been developed to a much greater extent.

A most successful furnace of this type has been constructed for the purpose of experimental firing and testing of refractories at high temperatures. The working chamber of this furnace has a floor area of

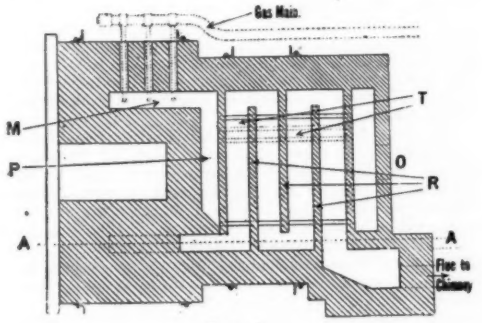


FIG. 3.

2 ft. 9 in. wide by 1 ft. 6 in. deep, having an arched roof with a minimum height of 20 in., thus giving a total volume of 10 cub. ft. The flame passes across this space horizontally and a very uniform heat is produced, the variation from the inlet end to the exit end being of the order of 20 deg. at temperatures in the neighbourhood of 1,500 deg. C. Temperatures as high as 1,650 deg. C. have been attained.

The general arrangement of this furnace is shown by means of two sections in Figs. 3 and 4. Fig. 3 is a horizontal section through the recuperator and mixing chamber, while Fig. 4 shows a part sectional elevation representing a section along the line AA, Fig. 3.

It will be seen from the horizontal section, Fig. 3, that the air entering at (O) passes through the tubes (T) into a collecting chamber (P), and thence into the mixing chamber (M). Here it meets the coal gas which enters through three horizontal tubes. From this chamber, where the flame is formed, the flame ascends vertically into the combustion or furnace chamber proper, which is placed at a higher level than the recuperator. After passing across the combustion chamber the hot gases descend and pass through the recuperator, being forced to take a long zigzag course by the three baffles (R). The arrangement of the tubes and the general construction of the recuperator itself are best seen from the photograph Fig. 5. The tubes are built up in 8 in. lengths and the joints are supported in the baffles, these baffles being themselves built up of special shaped firebricks. The recuperator contains nine courses of tubes, each course consisting of thirteen tubes, each tube being made up of four 8 in. lengths.

Perhaps the greatest difficulty which has had to be overcome in the construction of a furnace of this type is the prevention of cracking and breakage of the tubes as the result of thermal expansion shrinkage or other movements occurring in the furnace and the baffles. The first effort to secure this was made by endeavouring to leave the tubes as lightly held as possible in the apertures of the baffle blocks. This, however, did not prove entirely successful, and, in the course of time, the furnace suffered from the gradual destruction of the tubes owing to various movements occurring in the baffles. The device finally adopted has been to avoid attaching the baffles to any part of the furnace in any rigid manner. Where they stand on the floor of the recuperator chamber they are placed on a layer of dry grog of a refractory clay which does not become hot enough to adhere to the baffle blocks. This leaves the baffles free to expand equally in all directions. Anchorage to walls at the sides is also avoided by building the baffles loose and dry into slots formed in the side walls. The amount of leakage through crevices in these slots is very small, as the resistance to the passage of the gases is much greater through these small interstices than around the comparatively open paths which the gases are intended to follow.

So far as experience has yet gone this device promises to solve the difficulty to a very considerable extent and has certainly lessened the breakage of tubes very much. Even without the special device, however, the furnace illustrated has successfully withstood 62 heats, in many of which extreme temperatures have been attained. The furnace is still working, but the gradual breakage of tubes, due to the causes indicated above, has somewhat impaired its efficiency.

A second furnace on slightly different lines, again intended for melting purposes, has been constructed quite recently, the improvements in the recuperator construction indicated above having been applied to it with considerable success. An interesting feature in the case of this furnace is the provision made for the working opening in the crown of the melting chamber. This has been provided by means of a large circular aperture 14 in. in diameter, in a solid block made of silicon carbide, measuring in all 22 in. by 18 in. by 9 in. This block has been built of wedge

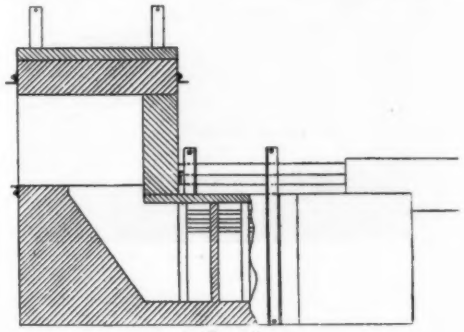


FIG. 4.

shape to fit in to the construction of the arch, and is proving eminently satisfactory under the somewhat difficult conditions which it is called upon to resist.

In connection with these furnaces, in which, as has already been indicated, very high temperatures are reached, some interesting experiences in regard to furnace linings and materials have been obtained. In the first furnace the lining of the combustion chamber was made of magnesite brick. This proved entirely unsatisfactory, as the brick failed very rapidly in consequence of "spalling." No doubt this was due to insufficient firing of the magnesite during manufacture. The magnesite lining was then replaced by one of crude zirconia bricks. These proved eminently successful from the point of view of heat conservation, the gas consumption of the furnace for a standard working temperature of 1,500 deg. C. being decreased from 1,200 cub. ft. per hour to 720 cub. ft. per hour. A marked diminution in the temperature of the external walls of the furnace in the neighbourhood of the combustion chamber was also clearly evident. This lining lasted rather longer than that of magnesite, but failed through much the same cause, viz., "spalling." Here again the manufacture of the brick was doubtless at fault. The evidence obtained shows clearly that if a zirconia brick of satisfactory quality can be produced it would materially increase the economy of gas-heated furnaces.

In the furnace illustrated in Figs. 3 to 5, the whole of the combustion chamber has been constructed of a good-quality firebrick, but it has been protected by a wash of silicon carbide made by mixing the powdered carbide with 5 per cent. of china clay, and applying this with a brush. In spite of the very high temperature which this furnace has frequently reached, the walls and roof of the combustion chamber, and of the passages leading to and from it, are quite sound after 62 heats. It is, however, necessary, in order to attain this result, to renew the wash of silicon carbide at comparatively frequent intervals, as, for instance, after five or six heats. If this is not done, the coating of carbide flakes off, the brick is exposed, and the advantage of the carbide coating is lost. For

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furnaces which are heated intermittently, so that access for repainting is possible, the use of the silicon-carbide wash appears to offer important advantages; in furnaces where the heat is long-continued this advantage may not be so great; even then, however, the possibility may be considered of applying the carbide in powdered form while the furnace is hot and the surfaces may be sufficiently soft to allow the carbide to adhere.

The draught used for the working of these furnaces is obtained from comparatively small chimneys, the stacks in both cases being less than 35 ft. in height. This draught is found sufficient so long as the furnace is in good condition; sometimes, however, it has been found desirable to accelerate the heating of the furnace, or to attain an exceptionally high temperature, by the application of a forced draught. This has been done by connecting the air inlet of the furnace to a low-pressure air supply derived from a fan. This expedient has, however, only been resorted to in quite exceptional circumstances, and the data given as regards gas consumption and temperatures refer to the use of the furnace with natural draught alone.

Some data as to the gas consumption and temperatures attained in various parts of the furnace may be of interest.

In the case of the kiln furnace described in reference to Figs. 3 to 5, the gas consumption, running at a temperature of 1,500 deg. C., is 600 cub. ft. per hour of town gas of approximately 500 B.Th.U. The air temperature, where the air leaves the recuperator, is between 250 deg. C. and 300 deg. C. below that of the working chamber of the furnace, so that the highest temperature attained by the incoming air is always by that amount lower than the maximum temperature attained by the furnace.

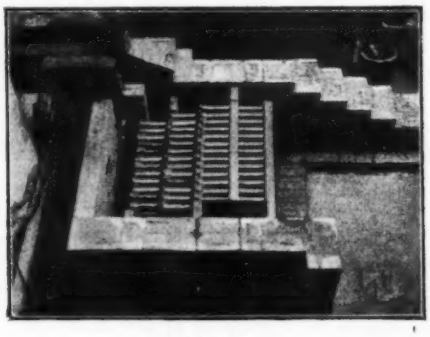

FIG. 5.

Temperatures attained by the tubes have also been observed. With a furnace running at 1,400 deg. C., it is found that the row of tubes nearest to the furnace chamber attain 1,200 deg. C., the second row 900 deg. C., and the third row 650 deg. C. It will be seen, therefore, that the material of the tubes is not exposed to any excessive temperature; but, on the other hand, the fact that these tubes of comparatively small diameter and thickness are required to bridge a distance of about 7 in. makes it very important that they should have ample power to resist any tendency to flow or sag, and it is probably for that reason that the use of silicon carbide has been found to be necessary. At the temperatures at which they are called upon to work in these recuperators there is no serious deterioration from oxidation.

It will be readily understood that the very efficient working of a furnace of this type can only be attained by combining with the efficient recuperation which this system affords an accurate control of gas and air supply. The author has found it useful for this purpose to use a recording instrument giving a record of the carbon-dioxide content of the flue gases, as this has provided a most certain means of securing a proper adjustment of gas and air. This being the case, it will be seen that the atmosphere in the furnace when working at fullest efficiency will be very slightly oxidising. If a larger excess of air is either drawn into or blown through the furnace, a more highly oxidising atmosphere can be maintained, but with a corresponding loss of efficiency, so that the furnace will not attain its full temperature. On the other hand, a slight restriction of the air supply will readily produce a reducing atmosphere, which, in this case, is accompanied by a much smaller loss of efficiency.

LABORATORY FOR RESEARCH. — The National Malleable Castings Company has opened at Cleveland, Ohio, a new laboratory which is to be devoted to research, the routine analytical and testing work required for works being carried on at the plant laboratories. The department occupies a three-storey building which is equipped for work in chemistry, physics, metallography, metallurgy, and materials testing. Mr. H. A. Schwartz is manager of research; Mr. H. R. Payne, chief chemist and acting metallographer.

The Safeguarding of Machinery.

At the recent Industrial Safety Conference, organised by the Home Office and the British Industrial "Safety First" Association, MR. G. STEVENSON TAYLOR, O.B.E., read a Paper dealing with "The Safeguarding of Machinery, with Special Reference to Machine Tools," from which we give the subjoined particulars.

In safeguarding the ordinary parts of machines, the following are regarded as the essentials of a satisfactory safeguard:—(1) It should prevent access to the dangerous part so long as the danger exists; (2) it should be constructed of such materials and in such a manner as to withstand the wear and tear to which it is likely to be subjected; (3) wherever practicable it should form an integral part of the machine and have been considered in its design; (4) it should, where necessary for intermittent dangers, be automatic in action; (5) its removal should not be necessary for the purpose of lubricating parts of the machine or the material under operation, or for changing belts, gears, etc.; (6) it should not introduce any fresh risk of accident; (7) it should be so hinged or hung as to be easily opened or removed when frequent adjustments and alterations are necessary, but in such cases should not be easily removable from the immediate neighbourhood of the machine: (8) it should not interfere unduly with the output of the machine.

Materials for Safeguards.

The selection of a suitable material for the construction of safeguards is a matter of utmost importance, but unfortunately often receives very scant attention from machine users and sometimes from machine-makers. Wood, cast iron, sheet metal, rods, tubes and bars of metal, wire work and expanding metal, mill board and papier maché may all be utilised, and may all prove satisfactory under particular circumstances. When substantially and firmly constructed of sound timber, wooden guards for such parts of machinery as pulleys, belts, small flywheels and shafting can be both neat and effective. The use of wood for guards has, however, many disadvantages; it is easily splintered and broken, readily absorbs liquids, and increases the fire risk

Cast iron is a particularly suitable material for the safeguarding of many dangerous parts of machinery. Guards of this material can be designed so as to form an integral part of the machine and to meet all other conditions which have been laid down. One objection often raised against cast-iron guards is that the gears or parts covered cannot be readily seen or oiled. Generally the guards can be removed at intervals to make an examination, and if there is any special danger of keys or screws working loose inside the guards, small sight holes with loose covers can always be arranged in them. Lubrication with the guard in place can nearly always be arranged, and in many cases the cast-iron guard will serve as an oil bath.

Sheet metal, especially sheet steel of suitable gauge, is an excellent material for guards. Simple forms of guards can be easily and cheaply produced by stamping when required in sufficient numbers, and can be made to conform to all the conditions which have been laid down for a satisfactory guard.

Rods, tubes and bars of metal are suitable for some classes of safeguards, especially those which are effective at a distance of 18 in. from the part of machinery guarded. Unless this is the case these materials should not be used except with small spacing, or in conjunction with sheet metal, wire work or expanded metal.

Wire work and expanded metal are similar materials for guard construction, except that expanded metal often has a somewhat sharp edge which may cause cuts and may also render it unsuitable for guards where delicate or fibrous materials are dealt with. Such guards, however, are likely to be deformed by rough usage, they do not exclude grit or dust from the parts covered, and they are difficult to clean, especially where fibrous dusts are produced or adhesive materials handled.

Millboard, papier maché, and similar materials have only been used in the construction of some patented types of safeguards for revolving shafting. Where, as on overhead shafting, they are not subjected to rough usage such safeguards have proved effective and durable.

Accident-producing Parts of Machinery.

The annual report of the Chief Inspector of Factories for 1913, the last normal industrial year, shows that 421 fatal and 47,177 non-fatal accidents were caused by power machinery in factories, docks, etc. Table I. shows the distribution of some of these accidents amongst various machines, etc.

The following are the principal accident-producing parts of machinery or machines in engineering works:—(1) Plain shafting, spindles, etc., bars and rods in automatic lathes; (2) projections such as set screws, studs, bolts, key heads on collars, couplings,

clutches, pulleys, etc., lathe carriers, drivers and jaws of chucks; (3) flywheels, armed pulleys and wheels; (4) driving belts, ropes and chains; (5) spur and friction gearing; (6) revolving cutting tools; (7) grindstones and abrasive wheels (bursts); (8) sliding and reciprocating parts, including plungers of presses, punches, etc.; (9) hoists and lifting appliances, cranes, etc. This list is not exhaustive, but it shows the principal sources of machinery accidents where safeguards can be adopted with advantage.

Forms and Types of Safeguards.

Shafting, etc.—All shafting within 6½ ft. of the floor, or within this distance of any place where persons have access whilst the shafting is in motion, should be efficiently safeguarded. It is not possible to guard the whole of the exposed parts of drill spindles, but additional protection could be fitted with advantage in many cases. Accidents due to clothing being caught by twist and other drills can only be prevented when a satisfactory drill holder is devised which will allow the drill to run free except when pressed on the work. The safeguarding of the shafts and universal couplings of milling machines is more difficult than that of ordinary shafting, as the shaft varies both in length and direction. Two telescopic lengths of tube with gimbal fittings at each end will generally meet the difficulty. Some machine tool makers have fitted cast-iron covers over the universal joints but have left the shafts exposed; others have fitted an open coil of wire over both joint and shaft, but this is only a partial guard and does not prevent a loose end of clothing from getting on to the joint or shaft. As in the case of line shafting the best form of guard consists of a tube or tubes completely enclosing the bar. The tubes can be carried on standards and adjusted to the length of the bar.

TABLE I.—*Machinery Accidents reported by the Chief Inspector of Factories for* 1913.

	Accidents.	
	Fatal.	Non-fatal.
Transmission Machinery:—		
Shafts	47	217
Pulleys and drums	6	360
Belts	12	1,155
Hoists (excluding breakage) ..	39	624
Cranes and winches (ditto) ..	85	3,863
Lathes	6	3,926
Grindstones bursting	2	25
Emery and abrasive wheels bursting	2	91
Presses (excluding punches) ..	—	1,113
Circular saws	7	2,637

Projections. — The risk of serious accident from revolving plain shafting, spindles, etc., is considerably enhanced if they carry collars, couplings, clutches, pulleys with any projecting parts such as set screws, key-heads, etc. All set-screws in collars and other revolving parts of machinery and machine tools should be recessed below the surface of the revolving part; and there is no reason why this simple precaution should not be taken on all new machinery. Where this is not practicable on existing machinery, the projecting screws should be properly covered with suitable sheet or cast metal casings.

Flywheels, etc. — For safeguarding flywheels, etc., standard and rail fencing may be satisfactory if double or treble rails are used and placed not less than 18 in. from the moving parts, the top rail being not less than 4 ft. from the floor, and if there is a covering of sheet metal or wire work either from the floor to the bottom rail or extending at least 6 in. above the floor to prevent tools, etc., falling under the rail. If it is necessary to carry the fencing closer to the flywheel or pulley, and on the whole close fencing is the more satisfactory, then the guard should extend to a height of 6 ft. 6 in. or to the top of the pulley or flywheel if less than this. The guard should consist of sheet metal wire work or other close material on a suitable frame. Flywheels and pulleys should be fenced on both sides as described if they have to be approached for any reason. The flywheel of a gas or oil engine is often well guarded on the outside, but on the crank side, where it is constantly approached by the attendant when feeling the bearings, it is frequently left quite unguarded.

The parts of overhead pulleys which are within reach of workers, i.e., less than 6 ft. 6 in. from the standing place, should be safeguarded underneath by strong sheet metal or other guards.

Driving Belts—Ropes and Chains.—Accidents from belts mainly arise (1) by trapping at the intake of belt and pulley, (2) by persons being caught by loose belts hanging on shafting, (3) by belt or belt fasteners striking a person, (4) from fracture of belt. Accidents from rope and chain drives arise chiefly from causes (1) and (4). Where a pulley is suitably guarded the intake of the belt will also be guarded. Many accidents at belt intakes are caused by persons removing, replacing, or shifting belts by hand. The danger in connection with the first two operations can be largely eliminated by the use of fast and loose pulleys and proper striking gear, also by the use of proper belt poles or mechanical belt shippers. A belt should never be allowed to rest on a revolving shaft owing to its liability to seize on the shaft and wind up, involving either accident to the person who may be touching the belt or injury to the machine with which it is associated. Belt perches, hooks or hangers should be provided for loose belts unless they can rest upon the guard provided for the shafting.

Driving chains are now largely used in connection with motor and other drives for machine tools. They should always be completely enclosed either by cast-iron or sheet-metal guards. The majority of machine-tool makers have embodied some excellent guards for chain drives in the design of their machines. The guards not only form an oil bath, but also a dust-proof casing for the chain and sprocket wheels.

Revolving Cutting Tools.—Milling machines are the principal machine tools with revolving cutters, which give rise to accidents in engineering shops. The majority of accidents occur on the narrow circular saw type of cutter, but also to some extent on other types. They are generally due either to the workers' fingers or hand or arm coming into contact with the cutter whilst reaching over the revolving cutter or whilst gauging his work. Guards for milling cutters should (1) prevent contact with the cutter, (2) be readily adjustable, (3) not interfere with a view of the work, (4) not prevent proper lubrication of the work. Several guards have been patented which comply with these requirements and some in addition facilitate proper lubrication of the work.

Grindstones and Abrasive Wheels.—The use of ordinary grindstones for tool grinding, etc., in engineering shops is rapidly becoming obsolete, but those stones are still largely, though to a decreasing extent, used in the grinding of cutlery, edge tools, textile machinery, stoves, etc. A satisfactory safeguard for an abrasive wheel should: (1) encircle the wheel as much as possible to prevent accident by contact and also to retain the fragments in case of a burst; (2) be strong enough to withstand the blows of the bursting fragments; (3) be so rigidly secured that it cannot be detached in the event of a burst; (4) be adjustable as the wheel wears; (5) cover the shaft end and nuts; (6) not interfere with the necessary dust removal appliance, and preferably should form part of such appliance.

Sliding and Reciprocating Parts.—Accidents are caused either by crushes between the moving parts and some fixed structure, or, in the case of quick moving parts like the tail rod of an engine, by a direct blow. Such parts as the latter can be readily safeguarded by being enclosed in a metal tube or covered with an inverted trough of sheet metal. Planing and similar machines with sliding parts should be fixed in the shop so that the part cannot run within 18 in. of any wall or other fixed structure, nor should it traverse any alley way or the space in front of any doorway. The beds of planing machines should be filled in with perforated sheet metal or similar material, as accidents have occurred through men either slipping into the bed or attempting to obtain tools stored therein (a dangerous practice) whilst the machine was in motion.

Accidents due to crushing of hand or fingers by the plunger on power presses of various kinds form an appreciable percentage of the total machinery accidents. The essential feature of a satisfactory guard for the plunger of a power press is that it should prevent the hand or fingers of the operator being under the plunger when the latter descends, whether its motion is due to the proper use of the controlling mechanism or to "repeating." It may be noted that the use of a double-handed control on presses does not obviate accidents due to "repeat" strokes. For straight blanking on small work and other simple operations, fixed guards are quite effective. They may be made of sheet metal, rods, or wire work, and should surround the plunger, merely leaving a narrow slot through which the sheet can be inserted.

Cranes and Lifting Appliances.—Accidents on cranes and other lifting appliances are mainly due to: (1) failure of the ropes, chains or mechanism; (2) failure or overturning of the crane structure; (3) overwinding; (4) unguarded gear wheels; (5) running over persons on track; (6) falls of persons. Regarding collapses and overturning of cranes, these are mainly caused by overloading, bad handling or defects in design. Overloading can be prevented to some extent by the use of load indicators and the employment of cranes suitable for the work. Overwinding can be prevented by the use of overwinding devices, of which several types, mostly electrical, are now obtainable. Falls of persons from cranes can be largely prevented by the provision of safe means of access, such as good stairways or ladders and platforms with handrails.

XUM

Institution of British Foundrymen.

SHEFFIELD BRANCH.

A meeting of the Institution of British Foundrymen was held at the Cutlers' Hall, Sheffield, on November 5, Mr. J. R. Hyde (Branch-President) in the chair.

Blow-Holes in Castings. By Dr. Desch.

At the outset the speaker said that as this was the first time he had attended a meeting of the Sheffield Branch of the Institution of British Foundrymen he wished to say how much pleasure it gave him to be with them. For a number of years past he had attended the meetings of the Scottish Branch of the Institution, and he thoroughly enjoyed those meetings. The subject of his remarks was one about which he really knew very little; his experience of the actual making of castings being very small. However, he wished to refer to some of the causes of blow-holes with what appeared to be a scientific explanation of some of them at least as it appeared to the metallurgist. Taking these causes in order, he proposed to deal first of all with those cases which he did not intend to discuss in any detail.

First of all there were the cases where blow-holes were caused by the trapping of air as the metal fell into the mould. He did not know how far those cases presented themselves in steel castings, but in the case of iron they certainly did occur. The trapping of air might take place in the making of small castings when the mould was being fed from a gate. This was a more frequent cause than was generally supposed in the making of iron castings, and he supposed the same would happen in the case of small steel castings. It was often due to mechanical causes that they had blow-holes. Some were due to defects in the moulds due to the use of sand in a composition which was too wet, or to the presence of wet patches or to blowing cores. A good deal of trouble was caused through cores blowing, and it was difficult to remedy them without altering the whole design of the casting. All these causes could be overcome by care in the moulding and in the preparation of the mould. What he wished to speak of more particularly was the subject of blow-holes due to gases which had originally been dissolved in the mould and then set free in the freezing. That class of blow-holes seemed to him to be more interesting than the others, because their causes were rather more obscure. In the class of blow-holes which they first had, they could be remedied by care in moulding, but in the class of blow-holes caused by gases they were dealing with something that occurred in the steel. When defects of this kind did occur there was liable to be a discussion between the manager responsible for the moulding of the castings and the man responsible for the making of the steel. It was just as well to look into the possible causes to see who was more likely to be responsible. They must look into the way that gases dissolved in molten metal, because owing to the peculiar behaviour of those gases conditions arose which gave rise to the formation of blow-holes when they might not otherwise be expected. They all got their idea of the behaviour of liquids towards gases by their experience of water. If they heated up water to boiling point they knew that it gave off a quantity of fine bubbles, but work that had been done showed that in this respect it was water that was abnormal and not the metals. Nearly all gases dissolved in liquids more readily as the temperature rose. Water was the exception, as it dissolved less gas as the temperature rose. Gas would dissolve both in liquid and solid metals and in both cases the solubility increased as the temperature rose. Liquid metal dissolved very much more gas than did the solid metal. In all liquids there was a comparatively gradual increase of solubility, but when they were cooled down to freezing point the quantity of gas they could hold was decreased very rapidly. After it became solid a smaller quantity still remained.

The speaker went on to illustrate his point by giving examples of tests that had been made. Copper to the weight of 2¼ lbs. was heated in contact with sulphurous acid, and then allowed to cool. At freezing that copper would give out 1,430 cub. cent. of gas. If the gas were hydrogen and the metal copper, the gas would only be about one-hundredth part of that. Iron would give off about 130 cub. cent. of hydrogen. They could, therefore, see what might happen in some other cases. Taking the case of silver he said that when it was melted it absorbed oxygen very rapidly. When silver was being melted and cast into the ingot they would see that a cover was put on the top to prevent it from spitting. They would see the top of the ingot rising at one stage when the metal was nearly solid and a workman beat down the top. If he struck too soon he would find the liquid metal spring up into the air. That was the release of the oxygen. If they examined blow-holes in castings not caused by the action of steam or air they would find inside the blow-hole no sign of oxidation. Hydrogen and carbon monoxide were the two gases usually present. When the metal began to freeze they had crystallisation which began from the side of the mould. These crystallites contained a small quantity of hydrogen and carbon mon-oxide. The rest of the gas had to be given off or absorbed in the process of freezing. If there was a way out it would rise and come out at the top of the mould. If it did not come out, bubbles of gas might be trapped between the growing crystallites, and in that gas they had blow-holes. Each of the bubbles of gas that remained was a blow-hole. The gas could not be held in solution and it could not escape.

Discussing the influence of pressure, Dr. Desch said that if they increased the pressure of gas which was in contact with the liquid the liquid dissolved more of the gas under higher pressure. One knew that very well in the case of aerated water. Carbonic-acid gas if pumped into water by applying high pressure was dissolved. It was impossible to see the gas in a full bottle of soda-water. If the pressure was released by taking out the stopper the gas came out. By doubling the pressure they doubled the quantity of gas that could be held. In the case of metals that did not hold, the amount of gas that could be dissolved was proportional not to the pressure, but to the square root of the pressure. Although the change with pressure was not so great as with water and carbonic-acid gas there was a change in that direction, and that was why some of the blow-holes were trapped in the lower part of the ingot before the whole was solid. It might well be that after freezing had taken place higher up there might be quite considerable internal pressure, and in that case gas, although present, might not come out of the solution. In that case they might fail to get blow-holes, although the quantity of gas was large enough to cause blow-holes had the pressure been low. In the upper part of the casting they might get blow-holes provided the gas was not able to escape through the head. Mr. Brearley, in his experiments with wax ingots, had clearly illustrated this.

Discussing the blow-holes that occurred in the furnace, Dr. Desch said that in the open-hearth furnace they had gases that contained oxides of carbon, also hydrogen and water vapour—hydrogen coming from the water vapour. There were a series of reactions going on in the bath, and these reactions were not over when the metal was tapped. In these reactions they had carbonic-acid gas reacting with iron to form carbon monoxide. As long as there were any oxides present in the steel, reactions would go on and they changed with the temperature. The more iron oxide they had the more carbon monoxide there was. Carbon monoxide was very soluble in the molten steel. Most of the carbon monoxide they had there depended on the amount of oxide in the molten steel. If they took away the oxygen they reduced the quantity of carbon monoxide, and if they gave the metal time the carbon monoxide that had been set free could escape. To get rid of the gas in steel it was essential to remove the oxide. If they got rid of the oxide completely there would be little fear of trouble from gases. The same thing held good very largely in regard to hydrogen. It must not be forgotten that reactions might go on after the deoxidiser had been added. De-oxidisation was not instantaneous. It was not possible, so far as he knew, to kill steel by any instantaneous process. Time was always required. There was the danger that the de-oxidation process

might be held up and they might pour the metal into the mould and then the reaction that had been suspended might start again, and there would still be carbon monoxide coming off. One reason for that must be that the giving off of the gas must always be rather slow. They knew if they took a bottle of soda water and released the pressure on the gas it did not come off instantaneously. It took some time to escape. The skill in making soda water seemed to depend largely on controlling that escape. When water held more gas in solution than corresponded with the temperature and the pressure it was said to be supersaturated. Steel could remain supersaturated with carbon monoxide for some little time. A small quantity of gas in contact with the metal would break up a super-saturated solution.

If they took silver, which would dissolve a very large quantity of oxygen it would give that oxygen out in spitting as it solidified. If they took an alloy of silver and gold they would find that it would dissolve very much less oxygen. As the quantity of gold increased they would find that the quantity of gas evolved decreased until the alloy would not spit at all. They would expect that alloying metals with steel would produce the same result. That was generally the effect though not always the case. Carbon monoxide was more soluble in the liquid steel than carbon di-oxide. As the metals were cooling down the reactions were going on, and it might be that the carbon dioxide coming into contact with the iron might form carbon monoxide. These were merely a few facts connected with the formation of blow-holes. It seemed that the question of solubility of gases in metals mainly affected the formation of blow-holes.

The discussion was opened by Dr. W. H. Hatfield, who described the lecture as a delightful one. Some of them had known Dr. Desch for many years, and it had always been a real delight to listen to him. His presence in Sheffield would be of great value to the metallurgical industries. He agreed in effect with the terms of the lecture, and he thought Dr. Desch had proved clearly that there was no excuse for blow holes in castings. The bottom of all the trouble was to be found in the foundry. Dr. Desch had taken a survey of the whole metallurgical field. That was the only way to look at these problems. There was no need to have blow holes in steel castings, because it was known that gas could be prevented from being evolved. He should like to ask Dr. Desch whether it was not a fact that sound steel, if carefully examined, was found to contain more gas than blown steel. He believed that it was an established fact that if silicon manganese or aluminium was added under proper conditions it made the steel capable of containing in a solid state the gas which would otherwise come off.

MR. BROWN disagreed that all the blow holes occurred in the moulding. Anyone who had any experience of steel castings must know that many blow holes were caused by oxidation. If some of the metallurgists went into the moulding shop they would learn a great deal. He pointed out the difficulty which arose when the steel was being run into the mould. It did not run to the end of the mould but overlapped, and that was where oxidation took place. Sometimes three or four castings are cast from the same heat, moulded from the same pattern, and dried all together in the same stove, and yet it is found that some are perfect after machining all over, and others present bad patches of blow holes.

MR. DARLEY asked for an explanation of the fact that sometimes they got different results from the same heat.

DR. DESCH, replying to the discussion, said he agreed with Dr. Hatfield that blow holes could be avoided when they knew how to prevent them. How to do it in practice was a very different thing. The more carefully they studied the question the more likelihood was there of turning out a casting free from blow holes. There was a difference between ingots and castings, because ingots had a uniform section. In castings there was inequality of pressure and much more liability to blow holes. He thought it was much easier to make sound ingots than to make sound castings. He agreed with Dr. Hatfield that the quantity of gas that could be extracted from solid steel bore no relation to the soundness of the steel. The unsoundness was not caused by the gas dissolved in the solid metal, but by the amount of gas not dissolved. He had been asked if aluminium increased the solubility of gas in the solid metal. He had not ventured before to express an opinion on that. The action of aluminium was not quite simple, but he did not think it could greatly increase the solubility of gas in solid metal. Aluminium would probably have more than only a minute effect on the solubility. Aluminium combined with nitrogen very rapidly. The point raised by Mr. Brown as to oxidation was important in that type of casting. He could not answer the question as to why one casting in a certain batch should contain blow holes and the others not. He did not think the killing of the steel was ever instantaneous. It took some little time for the killer to take effect.

NEWCASTLE BRANCH.

An Open Night.

A meeting held on November 27, 1920, took the form of "An Open Night," and several subjects were briefly discussed. Mr. George Vardy (Branch President), in the chair.

MR. M. GALLON, opened the discussion by giving a short Paper on "An Echo of the Glasgow Convention held in August," and submitted a summary of the several papers read at the Convention, with many comments thereon. After one of the papers, there was a discussion as to whether brass could be overheated. The lecturer at the Convention contended there could not be overheated brass, but that they could cast it at too high or low a temperature. There was a divergence of view upon that point. Although speakers persisted that they could overheat brass, the lecturer stuck to his guns and said he had heated brass to 100 deg. Cent. higher than he cast it at and he found no ill-effect. The discussion ended with "the doctors agreeing to disagree." With regard to a Paper by Professor Andrews, Mr. Gallon offered the opinion that they did not sufficiently watch the slag when running from the cupola; if it ran out like water, undoubtedly they were getting near the danger zone by introducing too much limestone, but if it ran out like thin treacle it was then fairly sure the limestone conditions were correct. Mr. Cathcart, of Glasgow, gave a helpful Paper at the Convention that was full of interest. Mr. Cathgart expressed the opinion that the craftsman with even a little science was a better and more useful man in the foundry. He (Mr. Gallon) thought they treated their workmen in a way they ought not to be treated. They ought to talk more with their workmen in order to get the best possible out of them, and if they did that, he believed the workmen would show more initiative, and altogether, they would get better results. If they had "a good thing" he was of the opinion they should share it with their fellow-men. Mr. Gallon concluded with an interesting description of a tour through Singer's works and of the many social events which added to the interest and enjoyment of the Convention.

Mr. Carmichael expressed the thanks of the meeting to Mr. Gallon for his informative remarks. With regard to overheating brass, he believed they could overheat it as well as they could overheat iron. That, of course, eliminated the zinc and other metals, although they certainly purified it in the process. With regard to the workmen showing more initiative, there were certain trades where there was very little initiative left for them to exercise, but he was a very ordinary moulder—in fact, he was no moulder at all—if he had no initiative. From personal experience he could say that there was no branch in the engineering trade that required so much initiative from the workmen as in the foundry, especially a jobbing foundry. The tackle differed every time, and there was a combination of circumstances to be overcome which was only gained from real experience, and a man had to exercise his brains if he was going to make a success of a job. A man was not a real moulder if he had to have two or three "wasters" first of all, to find out how to make a job. With reference to sharing secrets, he did not know that there were any secrets to be found in the foundry. Nobody had any monopoly of those so-called secrets, and

it was to overcome difficulties that they had such an Association as this, and when they went to the "High Court," (meaning the Annual Convention) of that Association, he thought they ought to set a better example or not to speak at all. They were much indebted to Mr. Gallon.

Mr. Young thought it was unfair to criticise a Paper in this manner in the author's absence, and he felt that he ought to take up the cudgels on his behalf. In spite of what Mr. Gallon had said, he was of opinion that prejudice against science did exist in foundries,—a good welcome seldom being given to a chemist. He (Mr. Young) did not know Mr. Cathcart, but he had read his excellent book. With regard to Mr. Gallon's comments upon Mr. Cathcart's solution of the forging problem, he had not read the Paper, but failed to see how it was possible to successfully heat-treat modern steel without scientific knowledge.

LONDON BRANCH.

At a meeting held at the Cannon Street Hotel, on December 9, Major W. Gordon, O.B.E. (Branch-President) in the chair, Mr. J. Feasey, of Lincoln, who has recently returned from America, read a Paper on American Foundry Impressions, of which the following is an abstract:—

American Foundry Impressions.

The Hog Island Plant of the American Shipbuilding Company on the Delaware River was first dealt with, and some startling figures were given with regard to its rapid construction. The contract authorising its construction was signed on September 13, 1917. Actual work was started seven days later. The yard was half completed by February 12, 1918, on which date the first keel was laid. The works cover 246 acres, and is served by 80 miles of sidings. It comprises 50 slipways, employing 30,000 workers. Fifty-six ships have already been launched.

Baldwin Locomotives, Eddystone, Pa.—On account of the slackness in the locomotive trade a variety of jobbing work is at present being undertaken. Locomotive cylinders are made solely from cores. Cast-iron pits for the mould-cases in which the cylinders are built are machined on the inside to a given size, to receive the cores and to make them form the correct size of the casting. The lecturer stated that this shop was unique, insomuch as that their four large cupolas were provided with receivers; this is probably due to the fact that they manufacture very heavy castings. Messrs. Baldwins usually employ about 14,000 men, and have a capacity for completing eight locomotives per day.

League Island Navy Yard.—A foundry has recently been added to the yard for making heavy marine castings. The shop, which is 600 ft. long, has three bays, the centre one being 80 ft. wide, and the side bays 40 ft. The centre bay is served by an 80-ton and a 10-ton electric overhead travelling crane, which is supplemented by 5-ton side travelling cranes. Two special features found in these works were (1) the charging platform, which was completely under cover, store rooms, lavatories, cloak rooms, and lockers were to be found on the same level. (2) The supporting columns of the shop were so constructed as to be a means of conveying hot or cold air according to the season. It is said that this shop cost 1¾ million dollars.

The Westinghouse Electrical Manufacturing Company, Philadelphia.—The foundry of these works is contained in a large shop served by two 75-ton, one 10-ton, and several 5-ton cranes. The heavy cast-iron pieces are usually cast from reverberatory furnaces of 40 tons capacity, which give a much higher grade material than can be obtained from the cupola at only a slightly increased cost. A British design of electric steel furnace (Greaves-Etchells) of 10 tons capacity, together with annealing ovens, are being installed. Whiting cupolas furnish the balance of the iron required, they are of 12 tons per hour capacity. The large charging platform extends for several yards under the crane serving the stockyards. Suitable boxes bring complete charges from the stock yard to the platform and run on lines to each side of the cupola. Both sides are simultaneously charged to obtain a level burden. The tipping of the trucks is actuated pneumatically.

Westinghouse Air Brake Company. — This foundry is designed for speed, a moving track enables them to make hundreds of air-brake cylinders per day. The precision of their green sand cores is excellent. For their core work they use a Hewlett-Demmter machine, which blows the sand into the core-box. The core department is on the second floor, and a conveyor carries the cores to the moulds. The drying of the cores is also a continuous operation.

Fort Pitt Steel Castings Company, McKee's Port, Pittsburgh.—This plant is engaged in making automobile castings by means of the cupola and converter process. Two tons of hot steel are cast every twenty minutes, giving a test of 30-tons maximum stress, and 8 to 10 per cent. elongation.

Fort Pitt Malleable Castings Company, McKee's Rocks, Pittsburgh.—One hundred and fifty tons per day is melted by this company in very large mechanically-charged reverberatory furnaces situated in the centre of the shop. Their well-designed shops are brick paved. The fact that they make small castings by means of snap-flask moulding possibly accounts for the fact that the core department is about one-half the area of the moulding department. The annealing ovens, which are in a separate department, are fired from gas producers placed at the back of each oven. The emptying and re-loading of the cars, which form the base of the furnace, on which the pans containing the castings are placed, is expeditiously carried out by means of an overhead crane.

International Harvester, McCormack Works, Chicago.—Their three grey iron casting shops are all provided with underground arrangements for sand mixing and conveying. The outstanding feature of this shop was a centrifugal machine for ramming up moulds. A fan, placed on the end of a double arm, similar to a two-joint gas bracket, is driven by a motor situate at the middle joint. The sand was fed down a gyrating shoot, and dropped on to the fan, which, by its speed, threw the sand into the moulding box with such force that it was sufficiently hard, and required no labour whatsoever. Four of these are at work and will shortly be supplemented by other four. After seeing this machine at work, one could imagine that in the near future an appliance would be designed which could be moved to any moulding box and ram it up without any other help.

In their malleable foundry they cast 50,000 light castings per day, mostly from snap-flask moulding. They are made from pattern plates. Two 20-ton reverberatory furnaces supplied with ¼-lb. pressure air blast under the ash pit and over the bridge supplies all the metal required. Two heats are made from each furnace per day. The construction of a 40-ton furnace of a similar type has been decided upon. The annealing ovens are built in batches of eight, and are heated by means of pulverised fuel, which is stated to give satisfaction. The annealing takes five days, its variation being checked by a meter situated in three places. Discharging and re-loading is carried out through the roof by means of an overhead crane. The tractor foundry when completed will cost 1½ million dollars. It is completely constructed of concrete, and is provided with an underground plant for sand storing and mixing, which is supplemented by three wide belt-conveyors for its distribution throughout the shop. In the core department, cores are placed by girls on stands, which are mechanically taken into the drying oven. Sand brought by conveyor always keeps full hoppers, which are placed above each core bench, and are opened as required. Much attention, as in most American foundries, is devoted to the welfare of the workers. At one end of the foundry there are four rows of rumblers, of graduated diameter.

North-Western Malleable Company, Milwaukee.—Automobile and railway castings constitute the bulk of the output of these works. Amongst other things, they turn out 6,000 malleable carburetter castings per day, for the Ford Company, in addition to many hubs and housings. Moulding machines are pneumatically operated. The metal is melted in coal fired, using forced draught, reverberatory furnaces, which make 12 tons per heat, and cast twice daily. Although wages have been

doubled, the pre-war output has been reduced by 40 per cent.

South Side Malleable Casting Company, Milwaukee.—Similar furnaces to those used in the North-Western Company's works are installed in the centre of a square shop. Although the furnaces tap on two sides, it takes half an hour to empty the furnaces, as shanking is used. To anneal the castings square boxes 1 in. in thickness with rounded corners made from a mixture of common soft and malleable scrap, are used. The boxes are packed in the open shops, and their base plates are provided with legs of sufficient length to allow of the charging machine foot to get underneath for transporting to the annealing oven.

The Nash Motor Company, Knoo.—Metal patterns working in conjunction with International Moulding machines are extensively employed. Very little extra space is given in the cast-iron boxes which they use. In this factory the men work in gangs of four to six in each. The percentage of wasters which used to be as high as 40 is now returned at 16. Girls are employed for making the smaller cores, and which are made from a mixture of 40 parts of silica sand to one of oil; men making the larger cores. Their aluminium core boxes are provided with vent holes to insure correct venting being established. The management of this works insists that the majority of cores require wires. Ten per cent. of steel clippings is introduced into the charge. Their output is 80 tons per day, and the average composition is 2.25 per cent. silicon, and less than 0.1 per cent. sulphur. A notable feature is that all castings are run through strainers in the runner box, and at the under side of the casting, for the purpose of keeping the casting free from slag and dirt. Core making occupies more than half the moulding personnel. Three hundred piston castings are made in one day by one man, using machines which require hand-ramming and placing four in a box.

Fairbanks Morse, Beloit.—Small gasolene engines are the speciality of these works. Continuous cupolas, rendered so by the use of a tipping spout, are reported to work efficiently. Four to six hundred engine beds are made by three or four gangs of men on International stripping plate moulding machines per day; this is rendered possible by the employment of the latest type of tackle and means of transport. Excellent results with bolt holes are obtained by enveloping cores in sheet asbestos coated with blacking. Running between the arms is reported to be a satisfactory method of casting small pulley wheels. The proportion of 50 parts of sand to one of oil, which is used for cores, is insured by the employment of an automatic filler and gauge.

Crane Company, Valve Works, Chicago.—As their name implies, their chief production is cast iron and steel valves, which are both manufactured under the same roof, the latter being made from convertors. As in most other modern American foundries, there is a most extensive underground system of sand mixing and conveying. The sand falls through gratings and is mixed below. Conveyors then take the prepared sand to above the moulding machines, passing throughout the length of the shop, and filling *en route* hoppers placed over each individual machine. This principle is additionally used for conveying finished moulds to the casting place, and returning the empty boxes to the starting point. Similar suspended tracks are to be found throughout the foundry. Casting is carried out by ladles suspended from mono-rails. An adjustment of about 4 inches can be made by means of a worm and wheel device. An endless chain with hanging racks for cores moves slowly between two rows of girls, who each place a standard plate full of cores on to it as it passes, is a unique feature in this works. The speed is regulated to keep the girls occupied. The filled racks pass through a heated chamber, sufficiently removed from the girls to obviate annoyance and then along to the core storage, without intermediate handling. Brass melting is carried out in both coke and oil fired furnaces, constructed in batteries of four, and arranged to turn about a post. At the first position the crucible is put in and packed round with fuel; at the next section the metals are charged up. The third turn brings it to the position where the special metals are added; whilst the fourth is the casting position. About 80 tons of non-ferrous metals are melted each day. The specification which they use for valves is: Tin 4, zinc 8, copper 75, and lead 13 per cent. An auxiliary pneumatic attachment to the cupola hoist gives a jerk to the material whilst charging, with the idea of levelling up the burden.

Alyns Ryan Foundry Company, Cleveland, Ohio.—From four to five hundred automobile crank cases is the daily production of these works. The moulds are made on Osborn machines, and are sprayed with benzole and plumbago. Although the best castings are run through a strainer, the yield works out at 80 per cent. Hand-charged Whiting cupolas, blown by Sturtevant fans, are used for melting.

National Malleable Castings Company, Cleveland, Ohio.—This foundry is said to be the best equipped foundry in the States, but as it has only been finished about a year it is not yet in full operation. Their castings are made from cupola metal, which is divided into two portions, one half being blown in a convertor and the other half being treated in an Héroult furnace. After 35 minutes the two metals are remixed, thus ensuring a regularity of product.

Cadillac Motors, Detroit.—The special feature noted by the lecturer existing at these works is a device for gripping a completely assembled set of cylinder cores, which on account of their fragility are mechanically conveyed to the moulders. It has lugs and pins exactly as in the moulding box. By this arrangement cores are placed quite easily into position. The release of springs is sufficient to make them ready to receive a further set.

Dodge Bros., Detroit.—This firm's foundry was described by Mr. Feasey as having the best lay-out for cylinder manufacture of any he had visited. The detail of moulding these cylinders was almost entirely accomplished with cores. The system of transporting the cores from the first floor to the moulding floor resembles a water wheel. The moulds, contrary to usual American practice, are dried. The castings, suspended from hooks, travel through the sand blast and on to the fettlers without intermediate handling. At the back of the fettlers' benches is a moving table, which carries the castings on to the testing department.

Ford Works, Detroit.—So much has been written about these works that few remarks should be necessary except those dealing with the foundry. However, to illustrate the enormous works for which the foundry has to cater, the following statistics are given. The Ford Works turns out every day 3,200 cars and 300 tractors, and employs 75,000 workers of 63 different nationalities. In the foundry there are six cupolas, each of which works eight hours in turn and together produce 300-400 tons per day. The usual transport facilities are well in evidence. The castings are knocked out over a grate floor, the sand dropping on to a belt conveyor, which takes it along to the sand mixing department. The foundry, using a converter, makes all their own steel castings for plant work, and employ a Greaves-Etchells electric furnace for special steel. The lecturer was informed that only two brands of metal were used; one for cylinders, which contains 15 per cent. of steel in the mixture, has the following composition:—Total carbon, 3.10-3.20; silicon, 2.20; manganese, 0.60; sulphur, 0.08; and phosphorus, 0.25 to 0.30 per cent. For all other purposes they employ a mixture containing 5 per cent. steel and giving the following analysis:—Total carbon, 3.30; silicon, 2.70; manganese, 0.50; sulphur, 0.08; and phosphorus, 0.40 to 0.50 per cent. Their piston ring pots are made by the centrifugal casting process, which they have recently successfully developed.

Additionally to purely foundry matters, much information was given on the social aspect of the tour.

The Paper was fully illustrated by a number of slides.

MR. T. J. BARNES, assistant solicitor to the Board of Inland Revenue, and acting solicitor to the Ministry of Shipping, has been appointed solicitor to the Board of Trade by Sir Robert Horne.

Aluminium and Its Alloys.—II*.

By W. Rosenhain, D.Sc., F.R.S.*

Pure aluminium in the cast condition, in the rolled condition, and even when hardened by cold-rolling is still too soft and weak for uses where heavy stresses have to be borne. It has accordingly long been the aim of metallurgists interested in aluminium to discover alloys which shall provide the desired strength, toughness, and stiffness. It must be remembered, however, that the feature which primarily makes aluminium attractive from the engineering point of view is its lightness, and it is therefore necessary that any satisfactory alloy shall combine, as far as possible, the desired degree of strength and ductility with a retention of the low specific gravity of the pure metal. With the exception of some special alloys produced by the addition of magnesium to aluminium, all the well-known alloys of aluminium are heavier than the pure metal. The superiority of any alloy over pure aluminium, therefore, depends upon the ratio which the improvement, brought about in the mechanical properties by the addition of the metals, bears to the increase of density which accompanies them. This ratio really determines the value of any alloy from the point of view of combined strength and lightness. The great difficulty in arriving at a numerical value, however, which shall furnish a just basis for comparison and classification of different materials, lies in deciding what typical property or combination of properties is to be regarded as indicative of "strength." In many respects one is accustomed to regard "strength" as merely equivalent to "tensile strength," and although tensile strength does give a valuable indication of the general typical character of a metal, it must be borne in mind that there are many other forms of stress to which materials are exposed, and that the resistance of a metal to pure tension does not necessarily measure resistance to shear, compression, or alternating stresses. If, however, we accept tests of tensile strength as our guide for the moment, it is possible to express the value of an alloy, from the point of view here under consideration, by a fraction in which the tensile strength per unit area is divided by the weight per unit volume. This ratio, to which I have given the name "Specific Tenacity," may be more precisely defined in the ordinary British units as being equal to the tensile strength in tons per square inch, divided by the weight of one cubic inch of the material in pounds.

Accepting the fact that it is necessary to improve the mechanical properties of pure aluminium before the metal can be used for many engineering purposes, we may next inquire how that improvement is to be brought about by the addition of other elements.

Certain elements when added to the pure metal do not remain uniformly disseminated throughout the crystals of that metal, but make their presence felt by the appearance of a second constituent in the interstices and boundaries of the original crystals. The second constituents produced in this way are always harder and stronger, but at the same time more brittle than the crystals of the original metal. When, therefore, the second constituent is present in small amounts, it serves merely as a strengthening and stiffening framework, which locks the crystals together and assists them to resist deformation by stresses applied from outside. This strengthening effect is, however, accompanied by a reduction in ductility, and when the amount of the second constituent becomes large this reduction in ductility becomes serious, and ultimately the alloy becomes brittle. The two types of alloys resulting from additions of metals, producing the two kinds of effects just described, are known as "solid solution" alloys and "duplex" alloys respectively. For the majority of purposes the solid solution alloy in which no second constituent is present has many advantages, particularly because it is possible to add much larger quantities of the alloying element if it remains in the form of a second solution, than if it becomes separated in the form of a second constituent. It is, however, possible to combine the advantages of both, either by using two or more alloying elements, or by using an alloying element which, while present in small amounts, remains in solid solution, yet appears as a second constituent when added in larger quantities.

In the case of aluminium we meet with this difficulty, that there are comparatively few elements which form long series of solid solutions with our metal. A long range of solid solution alloys can be formed with hardly any other metal than zinc; considerably shorter ranges of solid solubility are met with in the case of magnesium, copper, and nickel. On the other hand, in the case of such metals as iron, molybdenum, tungsten, vanadium, and others, the range of solid solubility is practically zero, and a second hard and brittle constituent makes its appearance almost as soon as one of these metals is added to aluminium.

The first example we shall consider is that of the alloys of aluminium with copper alone. These have received attention from investigators a good many years ago, one of the most important papers dealing with the matter having been published by my predecessor at the National Physical Laboratory, now Professor H. C. H. Carpenter, F.R.S., and Professor C. A. Edwards, in the Eighth Report to the Alloys Research Committee. From the present point of view, however, the most important detail of the equilibrium diagram is that representing the range of solid solubility of copper in aluminium. This it has been necessary to redetermine carefully by modern methods, for the purpose of arriving at more exact data than were formerly available or required. This portion of the equilibrium diagram is reproduced in Fig. 1. It will be seen that at a relatively high temperature (536 deg,

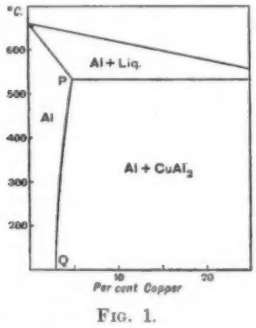

FIG. 1.

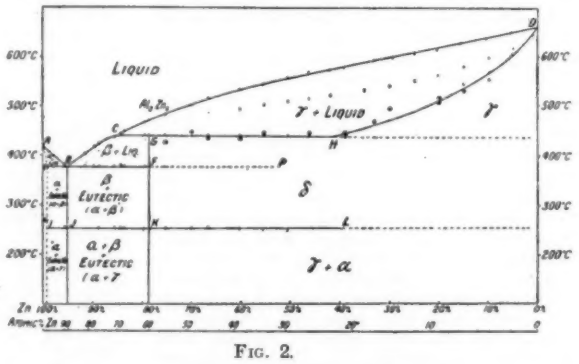

FIG. 2.

TABLE I.—*Copper* 4%. *Aluminium* 96%.

Condition.	Yield stress, tons per square inch.	Maximum stress, tons per square inch.	Extension per cent. on 2 inch.
Sand cast rod, 1 inch diameter ..	4.9	7.5	5
Chill cast rod, 1 inch diameter ..	5.4	9.6	10.5
Rolled rod, ¾ inch diameter ..	11.6	17.0	21
Drawn rod, ¾ inch diameter ..	18.5	20.0	7.5
Sheet, 18 gauge as rolled	15.9	18.6	4
Sheet, 18 gauge annealed 500° C. ..	4.9	11.7	25

C.), where solidification is just complete, a solid solution of copper in aluminium can exist which contains when in equilibrium as much as 5 per cent. of copper. This is represented by the point *P* in the diagram. The downward curved line *PQ* in the diagram, how-

* Abstracted from second Cantor Lecture before the Royal Society of Arts.

ever, indicates that the solubility of copper in aluminium diminishes with falling temperature, until at the ordinary temperature not much more than 3 per cent. of copper can remain in solid solution. It must be borne in mind, however, that the solid constituent, which separates from these alloys when the range of solid solubility is passed, is not copper, but an aluminium-copper compound $Cu\ Al_2$, a hard but brittle body possessing the characteristic properties of the second constituent referred to above.

With reference to Table I., the chill cast condition, this alloy attains a maximum stress of 9.6 tons per square inch, coupled with an elongation of 10 per cent. on 2 in. In the rolled condition it reaches a tensile strength of 17 tons per square inch with an elongation of 21 per cent., and by cold drawing the tensile strength can be raised to 20 tons per square inch, but the elongation suffers a corresponding fall. This alloy, it will be seen, represents a very considerable advance on the strength of pure aluminium, but it has been materially improved upon by other materials.

The mechanical properties of the alloy containing 12 per cent. of copper, the remainder being aluminium, are shown in Table II.

TABLE II.—*Copper* 12% (*Cast Alloy*).

	Chill (1in. diam.)	Sand (1in. diam.)
Yield stress, tons per sq. in. ..	6.4	5.0
Maximum stress, tons per sq. in. ..	9.7	7.9
Extension, per cent. on 2 in. ..	1.5	1

This alloy, of course, cannot be rolled or drawn, so that no comparison is possible with the higher figures of Table I. In the chill cast condition, however, this alloy with a tensile strength of 9.7 tons per square inch shows no advantage whatever over that containing 4 per cent. of copper, while it is appreciably heavier. Further, where the 4 per cent.

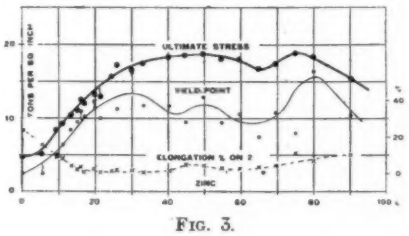

FIG. 3.

alloy shows an extension of 10 per cent. on 2 in., coupled with the same tensile strength, the extension in the case of the 12 per cent. copper alloy is down to 1.5 per cent.

The alloys of aluminium with copper alone can be slightly improved upon by the addition of a small amount of manganese. If it is not desired further to harden the alloy, the manganese should be used in place of part of the copper. Thus in the 4 per cent. copper alloy, 1 per cent. of copper may be replaced by 1 per cent. of manganese, giving an alloy containing copper 3 per cent., manganese 1 per cent., the remainder being aluminium. The mechanical properties of this alloy are shown in Table III.

TABLE III.—*Copper* 3%. *Manganese* 1%. *Aluminium* 96%.

Condition.	Yield stress, tons per square inch.	Maximum stress, tons per square inch.	Extension per cent. on 2 inch.
Sand cast rod ..	6.0	7.5	5
Chill cast rod	7.3	12.1	13
Rolled rod, $\frac{7}{8}$ inch diameter ..	12.8	16.5	15

Here the chill casting attains a tensile strength of 12 tons per square inch, coupled with an extension of 13 per cent. on 2 in. This is a very appreciable advance on the figures obtained with 4 per cent. of copper alone. There is also some evidence to show that the alloy containing a small amount of manganese has certain other advantages, particularly in regard to its power of resisting corrosion.

The next group of alloys to be considered are those consisting of aluminium and zinc. Their constitution and properties have been very fully described in the Tenth Report to the Alloys Research Committee of the Institution of Mechanical Engineers by the present lecturer, and Mr. S. L. Archbutt, in 1912. Considering first the constitution of these alloys, the equilibrium diagram is shown in Fig. 2. This diagram is admittedly incomplete in regard to one or two special points; it shows, however, that a series of solid solutions are formed containing zinc up to 40 per cent. The alloys which are of any practical importance, so far as light materials are concerned, are those containing less than 30 per cent. of zinc, and in regard to the constitution of these, at all events, there is no room for doubt. When brought into a condition of complete equilibrium, all these alloys show the typical structure of a solid solution closely resembling that of a pure metal. When these alloys are cast, however, they exhibit a markedly different micro-structure, arising from the fact that solid solutions during crystallisation deposit successive layers having different compositions, and these differences of composition are only removed by the process of diffusion which occurs when the alloys are subjected to prolonged heating, and particularly when heating is accompanied by mechanical work.

The mechanical properties of the alloys of aluminium and zinc, so far as tensile strength is concerned, are shown in Figs 3, 4, and 5, which refer respectively to the properties of sand castings, chill castings, and rolled bars $\frac{1}{2}$ in. in diameter, produced by hot rolling.

As regards Fig. 3, referring to sand castings, it will be seen that the ultimate strength increases up to, and slightly beyond, a zinc content of 40 per cent. In the case of chill castings, a first maximum is reached at 30 per cent., and a second higher maximum at 50 per cent. of zinc. In the case of the hot rolled bars $\frac{1}{2}$ in. in dia., the tensile strength rises up to a zinc content of 26 per cent., this being the limit of the alloys which can be satisfactorily rolled into bars and sheets.

In comparing the tensile strength of different members of this interesting series of alloys, however, it is important to remember that an increase of zinc content brings with it also a corresponding increase of density. Relative merits of the various alloys, therefore, are to be gauged in terms of their specific tenacity, a

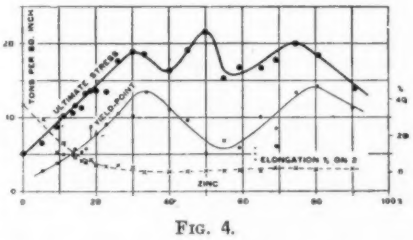

FIG. 4.

term which we have already defined as being measured by the ratio of tensile strength to weight per unit volume. This ratio and its variation with zinc content, in both sand and chill castings, is shown in the graph of Fig. 6. It will be seen that the maximum specific tenacity is reached in the neighbourhood of 25 per cent. of zinc for both sand and chill castings.

The comparison of specific tenacity is, further, of considerable interest, not only as between different members of the same group of alloys, but also as between the alloys of aluminium with zinc and those of aluminium with copper. This comparison is shown in the diagram, Fig. 7, which relates to rolled bars $1\frac{1}{2}$ in. in dia. Here it will be seen that the alloy containing 17 per cent. of zinc has a higher specific tenacity than any of the rolled alloys of aluminium with copper alone. With higher zinc content the specific tenacity of the zinc alloys attain still higher values.

While the mechanical properties of the aluminium-zinc alloys are themselves remarkably promising, further improvement can be obtained by adding to them small percentages of copper, thus obtaining ternary alloys of aluminium with zinc and copper.

In selecting an alloy out of a series, such as the aluminium-zinc series, in which specific tenacity increases with increasing zinc content, it does not follow that for any and every purpose it is desirable to use the alloy having the highest specific tenacity. It may be found, for instance, that unduly increasing the zinc content brings with it incidental disadvantages, such as difficulties in the foundry and others. Actually, the alloys very rich in zinc have the serious disadvantage that they are very soft and fragile when hot, so that they are very liable to be slightly cracked as the result of shrinkage or insufficiently careful handling. This consideration alone makes it desirable to keep the zinc content of an alloy, intended for extensive practical use, as low as possible. Further, castings particularly cannot be made of less than a certain thickness which is necessary to ensure the flow of metal into the various parts of the mould, and also to give the resulting piece sufficient robustness for handling in the workshop and

in practical use. The very high specific tenacity of an alloy, however, can only be fully utilised if weight can be reduced by reducing thickness. Where the limiting thickness is reached before the specific tenacity is fully utilised, it is preferable to use an alloy of actually lower density, in spite of the fact that its ratio of strength to density may be smaller than that of heavier alloys.

The effect of the presence of 3 per cent. of copper in an alloy containing 15 per cent. zinc is indicated in Table IV., which shows the yield stress, maximum stress, and extension per cent. on 2 in. of sand cast and chill cast test pieces from two alloys, one containing 15 per cent. of zinc without any copper, and the other containing 3 per cent. of copper as well as 15 per cent. of zinc. It seems that the presence of the copper brings with it an increase in tensile strength of from two to three tons per square inch.

TABLE IV.

	Sand cast.		Chill cast.	
	0 to 15	3 to 15	0 to 15	3 to 15
Yield stress, tons per square inch	9.6	9.8	5.8	7.0
Maximum stress, tons per square inch	11.1	14.4	11.7	13.9
Extension, per cent. on 2 inch	2	3	8.5	6.5

If the addition of zinc is carried somewhat further, a very interesting type of alloy is reached with a zinc content of 20 per cent. and a copper content of 3 per cent. The properties of this alloy in the cast condition, both as cast in sand and in chill, are shown in Table V. Here it will be seen that a tensile strength as high as 17½ tons per sq. in. has been obtained. Where light alloy castings are desired,

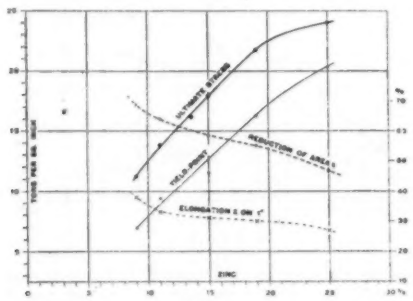

FIG. 5.

having the highest available tensile strength, there can be no doubt that this alloy offers advantages over the one previously described. It is, however, appreciably heavier and, unless the casting can be made proportionately thinner, advantage cannot be taken of the higher specific tenacity of this material.

TABLE V.—3 *to* 20 *Alloy.*

	Sand cast, 1 in. diameter.	Chill cast, 1 in. diameter.
Yield stress, tons per square inch ..	5.5	6.0
Maximum stress, tons per square inch ..	16.0	17.5
Extension, per cent. on 2 inch ..	3	5

It was soon found that alloys containing as much as 25 per cent. of zinc and 3 per cent. of copper could be rolled. This was proved by the fact that occasionally a bar of these materials passed through the rolls successfully. So long, however, as experiments on these materials had to be carried out in an industrial plant, no regular success could be obtained. This was no doubt due to the fact that in an industrial plant the rolling conditions must be accepted as they are found. It is not possible as a rule to introduce any material variations in the speed and other characteristics of the rolls available. This consideration, coupled with a full recognition of the very great importance of the part which aluminium alloys were likely to play in the future, particularly in connection with aircraft construction, led to the establishment at the National Physical Laboratory of an experimental rolling mill. The installation consists of an electrically-driven two-high mill, in which flat rolls for rolling sheet metal and grooved rolls for rolling bars and rods can be used interchangeably. The rolls are 2 ft. 6 in. wide and 15 in. diameter.

As the result of the careful study of the conditions affecting these alloys, both in the foundry, the rolling mill, and in the annealing furnaces, the difficulties in rolling these alloys have been gradually overcome, and it is now possible to roll a range of materials which, a few years ago, would have been regarded as quite outside the range of workable alloys. Not only this, but their rolling on a commercial scale has now been carried to such a degree of perfection that the loss by scrap can be kept negligibly small.

The physical properties of the hot-rolled material, as revealed by tensile tests, are shown in Table VI.

TABLE VI.—3 *to* 20 *Alloy. Tensile Tests.*

Condition.	Yield stress, tons per square inch.	Maximum stress, tons per square inch.	Extension, per cent. on 2 inch.
Rolled rod, 7 to 8 in. diam. ..	18.8	26.0	20
Sheet, 18 gauge ..	21.6	26.2	18
	22.1	24.9	17
„ 26 „ ..	20.6	27.6	12
	19.1	24.7	18

It will be seen that in this condition the alloys attain a very remarkable degree of strength and ductility, resembling that of mild steel. The tensile strength can be obtained as high as 26 to 27 tons per sq. in., combined with an elongation on 2 in. of from 18 to 20 per cent.

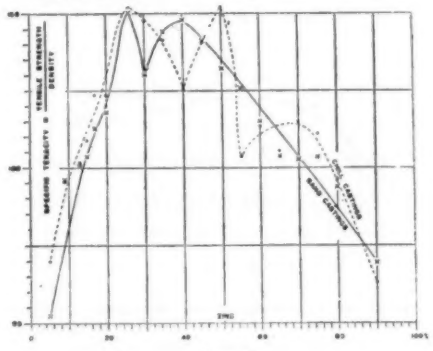

FIG. 6.

The next step in the development of strong and light alloys has consisted in the addition of an element which imparts to them the property of undergoing hardening, which in some degrees resembles that of steel. The element mainly responsible for such a hardening property is magnesium, whose use in this connection was discovered by Wilm in Germany, some ten years ago. He applied it in the first instance to the alloys which were then regarded as the best possible wrought alloys of aluminium, namely, those containing copper and manganese, such as are referred to above. These had first been thoroughly investigated at the National Physical Laboratory here, and an account of them has been published in the Ninth Report to the Alloys Research Committee. The German proprietary alloy "Duralumin" is, therefore, to some extent a direct descendant of the alloys studied here some time previously. The properties of the material obtained by the addition of a small amount of magnesium to the copper-manganese-aluminium alloys referred to are very remarkable. The material, when hot-rolled in the ordinary way, attains a tensile strength of not much more than 18 tons per sq. in. If it is then heated to a temperature a little below 500 deg. C. and quenched in water, its properties immediately afterwards are not very different from those of the annealed material. In the course of a few hours, however, the metal begins to undergo a change in properties. A hardening process occurs which gradually completes itself, at the ordinary temperature, in about four days. This process is represented diagrammatically in Fig. 8, in which Brinell hardness is the ordinate and time the abscissa. Typical properties of duralumin treated in this way are shown in Table VII.

When the development of the rolled copper-zinc-aluminium alloys had reached the stage indicated above, it was natural to endeavour to effect further improvement by seeking to apply to them the hardening action of magnesium. This has been successfully

done, and a series of alloys have been developed at the National Physical Laboratory which attain properties even more remarkable than those of "duralumin." Some additional difficulty in the manipulation of the

TABLE VII.—*Duralumin. Tensile Tests.*

Material.	Yield stress, tons per square inch.	Maximum stress, tons per square inch.	Extension, per cent. on 2 inch.
Rolled rod, 7 to 8 in. diam. ..	(1) 14.3	24.8	26
	(2) 16.5	25.6	28
Sheet, 18 gauge ..	14.0	26.7	21

(1) Cu. = 3 per cent. (2) Cu. = 4 per cent.

material is brought about by the introduction of magnesium, but these difficulties have been overcome by careful experimental study. The properties of the resulting material, which has provisionally been called "high tensile" alloy, are shown in Table VIII. The alloys have been prepared in various degrees of hardness, and the hardest and strongest of them can attain a tensile strength of 40 tons per sq. in. There can be no doubt that these high tensile alloys represent a very considerable advance on the combination of

TABLE VIII.
High Tensile Alloys. Tensile Tests.

Material.	Yield stress, tons per square inch.	Maximum stress, tons per square inch.	Extension, per cent. on 2 inch.
Rolled rod, 7 to 8 in. diam. ..	32.9	37.8	11.6
Sheet, 18 gauge ..	30.1	36.0	14.5
Softer Modification.			
Rolled rod, 7 to 8 in. diam. ..	26.0	34.0	20
Sheet, 18 gauge ..	30.1	34.6	13.5

strength and lightness which has yet been attained in aluminium alloys. That they are likely to find a very considerable degree of useful application appears probable. On the other hand, certain limitations must be recognised. It has, unfortunately, been found that alloys of aluminium containing both zinc and copper are peculiarly liable to corrosion, especially when exposed to contact with sea-water. When kept in the air in the ordinary way they retain their bright surface

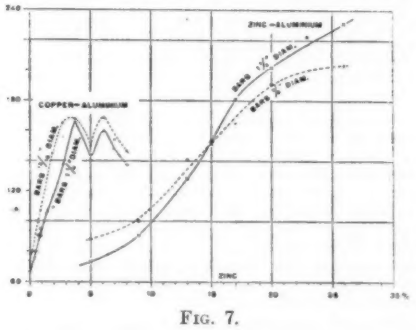

FIG. 7.

almost indefinitely. Immersed in sea-water, however, they rapidly deteriorate. This property must be borne in mind when any attempt is made to put such alloys into practical service. Where they are not exposed to contact with sea water, and where it is possible to protect them by a suitable coating of varnish or other protective material, no fear of undue corrosion need be entertained. Their physical properties are so remarkable that it is well worth while taking the trouble to ensure adequate protection from corrosion in order to avail ourselves of these materials.

In view of the limitations just indicated, an endeavour has been made to find alloys, if possible as strong in proportion to their weight as the "high tensile" series, which shall be free if possible from the tendency towards corrosion, which the former alloys exhibit. Investigation with this end in view led to a study of the alloys in which nickel is present, as well as copper and magnesium. These researches, which were in the first place directed towards the production of a casting alloy having special strength at high temperatures, have led to the development of a type of material which possesses very marked advantages. The tensile strength, even after hardening and ageing, is not as high as that of the "high tensile" series, although it may be hoped that future developments will lead to improvement in that direction. On the other hand, these alloys retain their strength at a higher temperature than any other wrought alloys of aluminium, and exhibit a very marked resistance to corrosion, even when in contact with sea-water. Typical of this group

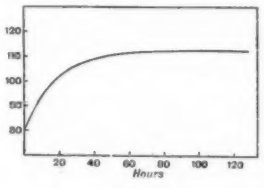

FIG. 8.

of alloys is one containing 4 per cent. of copper, 2 per cent. of nickel, and 1½ per cent. of magnesium, the remainder being aluminium. The properties of this alloy are shown in Table IX., but it should be remarked that

TABLE IX.—4/2/1.5 *Alloy. Tensile Tests.*

Condition.	Yield stress, tons per square inch.	Maximum stress, tons per square inch.	Extension, per cent. on 2 inch.
Sand cast, 1 in. dia. ..	7.9	11.1	1.5
Chill " " ..	9.2	12.7	1.5
Rolled rod, 7 to 8 in. dia.—			
As rolled	12.0	18.0	19
Heat-treated ..	14.3	24.0	24
Sheet—As rolled ..	22	24.5	3
Heat-treated ..	17.2	23.3	17

these figures represent conservative estimates of the results obtainable with this alloy. Since the data given in the above table were prepared, the alloy has been regularly produced with a tensile strength as high as 27 tons per square inch.

A comparison of the various wrought alloys which have been described is best made in terms of their specific tenacities, and a table giving the values of their specific tenacities in the ordinary units, and also in terms of miles of lengths of material which can just support their own weight, are given in Table X.

TABLE X.

$$\text{Specific tenacity} = \frac{\text{Max. stress (tons per sq. in.).}}{\text{Weight of 1 cu. inch (lbs.).}}$$

Alloy.	Condition.	Specific tenacity.	Miles supported vertically.
3 to 20 ..	Rolled, 29 tons per sq. in.	262	9
Duralumin ..	Rolled, 27 tons per sq. in.	268	9
H.T. ..	Rolled, 39 tons per sq. in.	360	12.6
Steel ..	Rolled, 30 tons per sq. in.	105	3.7

SHIPPING COMPENDIUM AND YEAR BOOK.—Compendiums, Limited, of 18, Old Compton Street, London, W.1, inform us that the Ship Compendium and Year Book, which is shortly to appear, is a work of upwards of 1,000 pages, and containing complete lists of the shipbuilders, shipowners, marine engineers, ports, harbours, dockyards, coaling stations, fuel oil stations, cable and wireless stations, naval architects, naval colleges, nautical academies and institutions, banks and bankers, dock and harbour commissioners, boards of trade, admiralties and their officials, ministries and boards of shipping, ministries of transport, shipbrokers, flags and funnels of the mercantile marine, technical and professional societies, benevolent institutions, salvage associations and shipping registries throughout the world. Tonnage and constructional statistics, the year's losses, ship and shipping law, insurance and indemnity, the British Admiralty and many other subjects connected with the shipping world will be exhaustively covered.

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Trade Talk.

THE BURNTISLAND SHIPBUILDING COMPANY, LIMITED, during 1920 launched seven steamers of 22,001 gross register tonnage.

BARIMAR, LIMITED, scientific welding engineers, announce the opening of a new branch factory at 150, Elizabeth Street, Brisbane, Australia.

OFFICES are being opened in Birmingham and Rome by the American Foreign Steel Corporation, of the Woolworth Building, New York.

FIFTEEN hundred iron-ore miners in Furness have received notice that they will be engaged only from day to day. The notice, as posted, gives no reason for this step.

THERE were at the end of the year 4,048 names on the unemployed register of the Sunderland Labour Exchange, of whom 3,520 were men, 258 women, 130 boys, and 140 girls.

MESSRS. RICHARDSONS, WESTGARTH & COMPANY, of Hartlepool, Middlesbrough, and Sunderland, last year built engines for 38 vessels, of an aggregate indicated horse-power of 96,270.

TWENTY-EIGHT days' notice has been given to 500 men in the various departments of Messrs. Guest, Keen & Nettlefold's Dowlais steel works, where a total of 6,000 is employed.

A ½-TON Rennerfelt electric-arc furnace has been installed at the San Francisco Mint. A 1-ton and a 1,200-lbs. furnace have been operating at the Philadelphia Mint for some time.

BROWN'S SHIPBUILDING AND DRY DOCK COMPANY, LIMITED, Hull, have during the year launched the "Royal Firth," of Newcastle, 420 gross tons and 350 i.h.p., and the "Chimera," of Peterhead, 96 gross tons and 270 i.h.p.

MESSRS. WILLIAM BEARDMORE & COMPANY, LIMITED, have in hand at their Coatbridge works a 320 b.h.p. 4-cylinder marine oil engine to the order of Messrs. Cammell, Laird & Company, Limited, Birkenhead, for the motor vessel "Fullagar."

SOUTH Wales returns show that nearly 15,000 workmen, chiefly miners, were summoned for non-payment of income-tax last year. In the Kenfig Hill district one defaulter earned wages which in the aggregate amounted to £1,000 a year.

UNEMPLOYED in the South Wales iron and steel industry now number 32,000. Seven tinplate works closed down at Neath last week. At Swansea, Llanelly, and Port Talbot, the majority of the tinplate works have also stopped.

AT a general meeting of the Institution of Mechanical Engineers, to be held at the Institution, Storey's Gate, St. James's Park, S.W., on Friday, January 21, at 6 p.m., Mr. H. J. Smith will read a Paper on "The Mechanical Loading of Ships."

THE firm of Richard Thomas & Company, Limited, on Saturday closed their rolling mills at Lydney and Lydbrook (Gloucestershire) because of the high cost of production and falling markets for tinplates. The finishing warehouse will go on another fortnight.

THE Board of Trade Journal states that the output of coal for the week ended December 25 was 4,541,600 tons, against 5,307,000 tons in the previous week. For the corresponding week in 1919 the output was 3,352,603 tons. The moderate reduction in output was due to the commencement of the Christmas holidays.

THE COUNTY OF LONDON ELECTRIC SUPPLY COMPANY is seeking Parliamentary powers in the coming session to constitute its Barking supply into a separate undertaking, with distinct capital and borrowing powers. The amount of capital to be allocated to the undertaking is to be determined at a general meeting called for the purpose.

A BILL to enable the Liverpool Mineral and Metal Storage Company to issue transferable certificates and warrants for the delivery of goods has been deposited for next session. The Bill proposes to confer the powers necessary to enable the company to issue transferable warrants or certificates on goods warehoused on their premises.

A FIRST-CLASS Atlantic liner now being built on the Clyde is costing £350,000, as compared with £115,310 for her sister ship built in 1912-13. The actual labour per horse-power has risen from £1.465 to £4.71. The net hull cost is £46 per ton, as against £17 per ton in the pre-war vessel. Wages have increased 32 per cent. since the contract was begun.

THERE is no slump of any kind in Belfast shipyards, where a record amount of tonnage is on hand. A full year's work is assured and Messrs. Harland & Wolff have three years' programme ahead, in addition to a large reconditioning programme, which will be augmented next week by the arrival of the White Star liner "Baltic" for six months' overhaul.

MR. GARY, chairman of the United States Steel Corporation, announces that his corporation has purchased one of the largest manganese mines in South America, at Morodamina, about 300 miles from Rio de Janeiro. He adds that the purchase renders the corporation independent with regard to supplies of manganese ore.

AT Portsmouth, the Admiral, Superintendents, and heads of Dockyard Departments have met in consultation with the Director of Dockyards upon the question of working short time as a means of alleviating unemployment. As an outcome the Admiralty have suggested to the Yard Committee that seven hours less per week should be worked instead of ten as originally proposed.

THE shipbuilding outlook on the Tyne is uncertain. a good many orders, especially for foreign owners, having been cancelled, and in other instances deferred delivery has been asked for, because these ships were contracted for at prices that could not be made remunerative in the prevailing slump in freights. The Tyne shipyards are now engaged entirely on merchant tonnage.

THE STANTON IRONWORKS COMPANY, LIMITED, have acquired the interests of Mr. John Cooper Shaw in the old-established limestone quarrying business of Bowne & Shaw, Wirksworth. The product of the Wirksworth firm, which owns more than a mile of quarries, is lime for building purposes, gas purifying and chemical manufacture, limestone macadam for roads, rubble stone for iron fluxing and chemical manufacture, etc.

MESSRS. RICHARDSONS, WESTGARTH & COMPANY, of Hartlepool, Middlesbrough and Sunderland, have during the past year achieved the highest output of marine engines in the United Kingdom. They have during the twelve months built engines for 38 vessels, the aggregate indicated horse-power being 96,270. In the returns for the whole world, Messrs. Richardsons, Westgarth & Company come sixth, and it is a significant fact that the first five are all American firms

MESSRS. PRICE, WATERHOUSE & COMPANY have announced the result of their ascertainment of the average net selling price of steel plates at Consett for the months of September, October, and November, 1920, which certified that the wages to be paid to the steel mill-men during January, February and March, 1921, will be 220 per cent above the standard, or, in other words, 10 per cent. above the wages prevailing during the last three months.

THE Secretary of the Iron and Steel Institute, Mr. G. C. Lloyd, in notifying an increase in the annual subscription, writes:—"Notwithstanding that this increase does not take actual effect until after the May meeting this year, the Council express the earnest hope that all members who habitually pay their annual subscription early in the year will kindly agree to accept the increase as from the beginning of the year, and make their payments for 1921 at the new rate of £3 3s."

THE Barrow works of Vickers, Limited, are now completely turned over to peace industries. Locomotive repairs are still proceeding in large numbers. The shops, which during the war period were busy with naval and field guns and mountings, are now turned to the manufacture of high-class rubber-making machinery, gyratory crushers for cement making, mining machinery, gas engines for steel works, while an important and rapidly developing industry is the manufacture of centrifugal separators for agricultural purposes.

AT the annual source of the Birmingham Scientific Society this week exceptional interest was taken in Mr. Dallison's automatic pilot, which has been experimented with for some time past. It is an apparatus by means of which an un-manned ship can be kept on its proper course. A vessel fitted with this contrivance can be run up the channel of a river with accuracy. Experiments have been conducted on a British gunboat, the results of which have given considerable satisfaction, and proved the value of Mr. Dallison's invention.

THE South American Copper Syndicate has received information by cablegram that the Court of Appeal has affirmed the judgment of the Supreme Court, New York, with costs, in the action to establish certain contracts for the sale of its production. This, the final decision, secures to the company (says an official statement) the full advantages of the contracts for a period of eight years, with five years yet to run, the fulfilment of which the New York buyers attempted to avoid owing to the greatly increased cost of metal refining since the contracts were entered into.

THE finely modelled geared turbine steamer City of Glasgow, built by Messrs. William Gray & Company (1918), Limited, West Hartlepool, for the Ellerman Lines, Limited, Liverpool, has successfully passed her sea trials. The ship is equipped to meet the owners' special requirements for the trade in which she is intended to run. The double bottom is arranged for carrying oil fuel. The propelling machinery consists of one high pressure turbine of the impulse type, and one low pressure turbine of the reaction type, and the boilers are specially designed for burning coal or oil fuel.

IRON AND STEEL MARKETS.

Pig Iron.

A very slow recovery after the conclusion of the holidays is a distinctly marked feature in the week's pig-iron markets, business continuing extremely sluggish, with very little disposition on the part either of buyers or sellers to impart more activity in current movements. In South Staffordshire smelters so far have made no formal change in their quotations, pending a conference between the furnace owners and their coke supplies. But the market is disorganised meanwhile. Business could, however, be transacted at prices considerably lower than some of those currently quoted. Forge iron might be obtainable at £11, and a low-grade South Staffordshire make was on offer at £10 10s. Some holders of foundry iron were ready to do business at 15s. to 20s. below the rates recently ruling. In other departments of the market the tone was very depressed. In the West of Scotland business in pig-iron has been in reduced volume of late owing to the extended holiday celebrations, and operations at several of the local furnaces have been partially suspended There is, however, a fairly good demand maintained, and as yet no weakening of prices has transpired. For the present buying both of foundry and hematite qualities is for practically immediate requirements, probably in anticipation of a movement in the direction of lower prices, which may, or may not, materialise. Probabilities, however, are favourable to a gradual lowering of quotations in the near future, following the example set by Cleveland makers. At Sheffield the market for raw material maintains a fairly firm tone, but buying at present is not on a large scale, with price movements without special significance.

In Lancashire foundry prices are unchanged, but a meeting of pig-iron and coke men is to be held, and it is believed that some attempt will be made to readjust the prices of coke, so as to make it possible for iron makers to reduce their prices. In the present state of the fuel supply it is unfortunate that anything should be done to curtail the output. There is practically no business passing in foundry iron pending the rearrangement of Manchester prices, but the possibility of getting down the prices sufficiently to satisfy the present mood of the Lancashire ironfounders is not promising. The Tees-side market at the week-end meeting was met with the announcement of an all-round revision of prices for Cleveland iron, which could hardly have been anticipated, but was certainly advisable in the conditions now ruling in the trade. For some time past it has been the consistent policy of Middlesbrough smelters not to exploit the situation by forcing up prices, and, although Cleveland iron is to-day the cheapest in the country, it has been recognised that even the present level of prices is too high for the continued prosperity of industry, as a whole. Accordingly the makers have resolved upon an all round reduction of prices. Broadly, it may be said that 10s. has been taken off the price of the standard foundry quality, the premium for the higher qualities has been reduced, and for the first time for a period of years the differentiation in price as between No. 3 and the lower qualities has been restored. The full list of quotations now represents the following values :—No. 1 Cleveland, home 225s., export 245s.; Silicious iron, home 225s., export 245s.; No. 3 Cleveland G.M.B., home 215s., export 235s.; No. 4 foundry, home 214s., export 229s.; No. 4 forge, home 212s. 6d., export 217s. 6d.; mottled, home 212s. 6d., export 217s 6d.; white, home 210s., export 215s.; hematite East Coast mixed numbers, home 240s., export 245s.; No. 1, home 242s 6d., export 247s. 6d. Rail deliveries during December are said to have been the heaviest during the whole of the year, and the result is that consumers are now heavily stocked. Moreover, the works and foundries are not nearly so busy, and their needs are on a smaller scale. Thus even for foundry iron, hitherto so scarce, there is distinctly less inquiry, and January seems likely to be a quiet month. Business in the Cleveland iron export market is again restricted to a minimum, chiefly owing to the disorganisation of the exchanges which presents insuperable difficulties to increased trade in this direction. It is the abnormal state of the exchange which enables Belgium to undersell us in the home market. Concerning Belgium it should be remembered that she is now exporting on a big scale, and this, of course, tends to raise the value of the Belgian franc, which, in turn, renders it less easy for the Belgian manufacturers to undersell us here. Nearly all the Belgian contracts are short date contracts, and an alteration in the rate of exchange might speedily shut them out of our markets.

In the case of Italy, they wish to buy, but exporting little, their currency is so depreciated that they cannot afford to pay our price. That is the difficulty, and if it can be surmounted foreign business will rapidly improve. Meanwhile the export trade is almost dead. East Coast hematite, notwithstanding the reduction in price mentioned above, is only a slow market, the buying since the opening of the new year having been on quite an unimportant scale. Demand has, of course, decreased with the inactivity in the steel trade, but it is hoped that the reduced price may stimulate inquiry for export. The position of the hematite trade of North Lancashire and South Cumberland is very far from being satisfactory, and there is a depressed feeling generally throughout the district. Whilst orders are still held on old contracts, new business is not coming to hand, and there is every chance of a reduction in output in the immediate future. There is no desire on the part of smelters, owing to the very high cost of production, to again run iron into stock, as was done on many occasions years ago. The business doing is only on a small scale, with orders given out to cover immediate requirements only. So far as Barrow trade is concerned there is a certain demand on the part of iron founders, but the closing down of the local steel plant has cut down consumption on the spot considerably. The recently reduced price of £13 15s. per ton net f.o.t. is quoted for mixed numbers of Bessemer iron, with special brands at £15 to £15 10s. per ton net. Lower rates are expected before long.

Scrap.

In all the principal markets where dealings in scrap material are transacted depression continues the dominant note, and with many works already overstocked, there is increasing difficulty in disposing of even best qualities except at a very substantial reduction in price. In Lancashire the trade is quiet if not completely stagnant, dealers asking about £11 for good qualities of broken cast iron, but with very few buyers about. There seems to have been a further fall in wrought scrap, and some Lancashire consumers are now offering only £7 per ton for it. On the North-East Coast in regard to steel scrap, the works are either heavily stocked and are not prepared to buy at present, or are so badly off for orders that they are off the market until there is a distinct revival of business In the Welsh market heavy steel scrap is offered at £6 c.i.f. to £7 10s.; bundled steel scrap and shearings are quoted from £6 to £7, according to the method adopted in bundling There is no demand for mixed iron and steel scrap for basic furnaces, and large quantities are on offer at prices ranging from £2 to £6, according to quality. Heavy cast-iron scrap in lumpy pieces for basic furnaces is quiet at about £8, and good machinery scrap for foundry purposes is slow at about £10 10s. delivered.

Finished Iron.

One of the most noteworthy features of the operations in finished iron last week was the decision of the S. Staffs. marked bar manufacturers to reduce prices to £2 per ton, making the selling price £31 10s., to take immediate effect. This movement was preceded a month ago by the makers of unmarked bars, and it was then hardly expected that the better qualities would follow on similar lines, the latter being much less exposed to outside competition, and, so far, demand generally exceeding supplies. For the past seven months marked bars have been selling at £33 10s., which is practically double the price at which they stood when the war concluded. They were advanced six times in the course of as many months between the end of 1919 and last June. Prior to 1918 the record price for marked bars was £15. This figure was touched in March, 1873. When war was declared in August, 1914, the price was £8 10s., roughly one-fourth of the record from which we are now receding. Makers of marked bars, however, have for the present a fair volume of orders on hand, but new business is admittedly less satisfactory, although they have so far not been subject to cancellations of orders as have some of the rollers of the inferior grade material. The latter, indeed, are passing through an anxious time, some plants not having re-started since Christmas, while in other cases mills have only a few days' work in hand. So far as the nut and bolt trade is concerned, Belgian shippers are competing strenuously for the British market, and prices substantially lower than any previously quoted are now mentioned both for bar iron and soft billets. Nut and bolt makers have mostly large stocks of the Continental bars in store, out of which they are able to execute the orders in circulation. Last week new price-lists have been issued by Messrs. Stewarts and Lloyds for wrought-iron tubes and fittings for water, gas, steam, etc. There has been a revision of all descriptions, some having been slightly increased, and others unaltered, but the general effect is to reduce prices, in the case of tubes by nearly 5 per cent. and in the case of fittings to a larger extent. Business is less active in these lines. In Lancashire the finished iron trade gives little indication of improvement, and the home prices, held at from £7 to

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£10 above Continental quotations, do not inspire confidence in an early revival of active buying.

The Trade Board established to deal with the chain trade, announces in the "London Gazette" that it has been decided to vary the general minimum piece rates for making dollied or tommied short link chain, or short link hand-hammered chain. The time rates are to continue in operation.

Steel.

The outlook in the steel trade is by no means satisfactory, but it is at least gratifying to record that a movement is in progress for cheapening the cost of production, which may have far-reaching effects upon the course of business in the near future. As expressed on many occasions in the trade Press, one of the chief obstacles to reducing expenditure of makers has been the enormously inflated cost of fuel, which, under the influence of a recent world-wide demand, had soared to unparalleled heights in selling prices, which substantially enhanced the values of all descriptions of finished and semi steel products. For some time negotiations have been in progress with a view to coming to some arrangement with regard to reducing prices of essentials, and accordingly a joint conference of the members of the Coke Association and the ironmasters of Sheffield and district was called at Sheffield on Friday last for the purpose of considering the present condition of the respective industries. After a full discussion of the subject it was provisionally arranged to reduce the price of furnace coke, as from January 1, by 10s. 9d. a ton, making it 55s. at oven for inland purposes and 65s. f.o.b. for export. The decision is regarded as important, as it will enable the makers of pig-iron to reduce their prices, and consequently bring the price of finished iron and steel down towards a figure at which British makers will be in a better position to meet the growing foreign competition. It is of course premature to speculate on the effect this decision will have on prices in general, but the tendency to reduction of values for all kinds of steel products must unquestionably be accelerated by the movement with regard to fuel costs in the various processes of manufacture. At Sheffield, the principal departments of steel production may be described as much quieter than usual, and though there are no evidences of any panicky symptoms, the prospect of this year's business cannot claim any distinctly reassuring features. The recent slump in shipbuilding will be especially unwelcome at this juncture, a large output of steel plates employed in that industry being produced by Sheffield firms. Another branch of local trade similarly affected are the steel foundries, which, depending as they do for a considerable part of their output on shipbuilding, are likely to experience a quieter time in the near future. There is still a fair inquiry for small castings. The inactivity of the motor industry is, of course, responsible for much of the local depression. An immense volume of trade with the Continent is being held up by the heavy depreciation of the exchanges of those countries. In the Scottish steel market there has been little business passing since the holidays, and some of the works still remain idle. At a meeting of Scottish steelmakers, held in Glasgow at the week-end, it was resolved to reduce home prices as from Monday to the extent of from 30s. to 10s. per ton, according to the class of material, and from that date boiler plates will be quoted £30, ship plates, ¾ in. and up, £24 10s., and sections £24, all basis prices net, and subject to existing extras and conditions. This is the second reduction announced since the trade decline set in. There is nothing doing in the steel industry at Barrow, with the exception of the hoop mills. Repairs are being carried out to engines and plant. The outlook in the steel trade is poor all round, with a small demand for sections or castings, and foreign competition is keen. Steel prices are unchanged. The Board of Trade Returns for December just issued record gratifying increases in iron and steel and manufactures thereof in the first-mentioned class of £2,216,897, and of £3,677,810 in machinery. The huge advance of £536,930,665 in exports in 1920 compared with those of 1919 was in part made up as follows: Raw materials and materials mainly unmanufactured, £34,364,862; articles wholly or mainly manufactured, £479,247,324. Analysing these figures in detail, it is interesting to note the following advances under the heading of articles wholly or mainly manufactured: Iron and steel and manufactures thereof, £64,519,108; vehicles (including locomotives, ships and aircraft), £46,234,997; machinery, £32,716,436; coke and manufactured fuel, £11,608,124; and non-ferrous metals and manufactures thereof, £11,497,579. It is noteworthy that not a single item in this class recorded a decrease.

Ore.

Ore freights continue on the downward tendency, the rate from Bilbao to the Tees being now probably no more than about 13s. The nominal price of best rubio ore rules at 49s. on a 17s. freight basis, which would bring the c.i.f. price into the neighbourhood of 45s., but there is actually no business passing, and possibly the 49s. quotation would be shaded for suitable business. The decline in furnace production is certainly affecting the native iron ore industry, and already some thousands of miners are under day-to-day notice in the Cumberland and North Lancashire area. Several of the mines, it is feared, must be closed down. None of them, it is stated, will bank ore if it cannot be sold. The superior kinds of ore, however, are in fairly brisk demand.

Tinplates.

It is many years since the tinplate trade experienced the severe depression now prevailing throughout the industry, in which practically half of the works have suspended operations, pending a revival of demand. A representative meeting of the Welsh tinplate makers at Swansea last week considered schemes for stabilising the industry, and reducing the prevailing unemployment. The committee, which has been sitting constantly for the past fortnight, was enlarged, and an official report of the proceedings states that there are hopes they will be able, at a subsequent meeting of the trade, to put forward a scheme that will meet with general acceptance. On the tinplate market varying views are expressed as to how long the depression is likely to last, some insisting that the restriction of output will bring in foreign buyers, whilst others predict a depression over three and even six months. More moderate opinion inclines to the view that it will last until European credit is restored. The market in Welsh tinplates remains quiet. Stock plates have been done at 33s. per box basis f.o.t., but ternes are firm at 37s. 6d. f.o.t. Wasters, on the other hand, are easier at 30s. basis f.o.t. American advices state that owing to financial trouble in the Far East and South America, large parcels of tinplates have been held up, whilst generally the trade there is dull, tinplates being around $7, with no export business passing. Current quotations of Welsh tinplates are: Cokes, 20 x 14, 33s., 36s.; ditto quarters, 35s. 6d., 38s.; cokes, 20 x 10, 48s., 50s.; ditto, 28 x 20, 66s., 72s.; ternes, 74s., 76s.

Metals.

Copper.—The week's markets opened with a further indication of improvement on the previous closing prices, with forward business a feature of the day's operations. Inquiries on consumers' account were in better volume, and values all round developed a firmer tendency. Refined qualities were again steadily supported, electrolytic showing an appreciable advance, while wire bars were also stronger, with a substantial turnover. Closing Prices:—*Cash:* Wednesday, £72 7s. 6d.; Thursday, £72 15s.; Friday, £73; Monday, £74; Tuesday, £74. *Three Months:* Wednesday, £73 5s.; Thursday, £73 15s.; Friday, £74; Monday, £73 5s.; Tuesday, £74.

Tin.—Business in the East continuing idle, an inactive tendency developed in the market here, but later moderate buying on forward account was in evidence, and, lacking selling pressure, only a limited decline was registered in both positions. There was no change in English ingots. The weekly official return of tin stocks in London warehouses shows an increase of 452 tons on the week to 4,443 tons. Liverpool stocks at 1,534 tons have appreciated 101 tons, while the Swansea stock at 112 tons shows a decrease of four tons. Closing Prices:—*Cash:* Wednesday, £205 10s.; Thursday, £208 5s.; Friday, £210 10s.; Monday, £210; Tuesday, £209. *Three Months:* Wednesday, £209 15s.; Thursday, £213 5s.; Friday, £215 15s.; Monday, £210; Tuesday, £213 15s.

Spelter.—Transactions in this week's opening market were confined within very narrow compass, but with holders very reserved all positions closed with an advance in values. Business was almost solely restricted to April deliveries, ranging from £27 15s., to £27 17s. 6d.

Lead.—The tone of this market is steadily maintained on forward account, and as sellers were not pressing prices were higher. January was done at £23 to £24; February, £24 5s.; March, £25 10s. to £24 10s., and April at £24 10s. English lead was a quiet market, closing with an advance of several shillings at £26 net.

PARTICULARS of a series of £2,000,000 debentures created by Bolckow, Vaughan & Company, Limited, on November 9, have been filed pursuant to Section 93 (3) of the Companies (Consolidation) Act, 1908. The amount of the present issue is £1,000,000. The debentures are charged on the company's undertaking and property, present and future.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

The Mastery

of the Air.

SIROCCO TRADE MARK

FANS

SEND US YOUR ENQUIRIES FOR

are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

Davidson & Co., Limited, *Sirocco Works,* BELFAST.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.

CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

Established 1872. ***Telegraphic Address: "Steel, Glasgow."***

XUM

Public Companies.

Reports and Dividends.

Hall & Company, Limited. — Interim dividend on ordinary shares to September 30 last at the rate of 1s. per share, less tax, payable January 31.

Eastern Smelting Company, Limited.—Dividend of 5 per cent. (1s. per share) on preferred ordinary shares for half-year, making 10 per cent. for year; £4,340 for depreciation; £21,253 forward.

British Electric Transformer Company, Limited.—Profit for half-year ended June 30, 1920, was £35,344, which compares with £21,419 for same period of 1919. Since January, 1920, the works have been quadrupled in size, and output is steadily increasing.

J. Hay & Sons, Limited.—Private company. Capital £250,000 in £1 shares. To carry on the businesses of shipowners, shipbrokers, managers of shipping property, shipbuilders, engineers, etc. The first directors are: W. Hay, J. Hay, and J. Hunter. Registered office: 58, Renfield Street, Glasgow.

Mackay & Smith's Light Castings, Limited, Dunterlie Iron Works, Barrhead. — Capital £2,500 in £1 shares. Private company to acquire and carry on the existing business of ironfounders. Subscribers:—E. W. Smith, merchant, 35, Miller Street, and James G. Winter, solicitor, 83, West Regent Street, Glasgow.

Guest, Keen & Nettlefolds, Limited.—The directors have declared an interim dividend for the six months to December 31 last at the rate of 5 per cent. per annum on the first and second preference shares and 1s. per share on the ordinary, both free of tax, payable February 10, to holders on the books on January 15.

Siemens & Halske Electrical Company, Germany.—The shareholders have sanctioned the fusion, and also all the other Siemens' interests, with the Rhine-Elbe Union, the greatest of Hugo Stinnes' trust creations. Siemens & Halske will increase their capital to 260,000,000 marks by the issue of 130,000,000 preferred shares and 4,000,000 ordinary shares. Herr Stinnes has been given a seat on the Board of Control.

W. S. Laycock, Limited.—The debenture-holders of W. S. Laycock, Limited, railway carriage makers and engineers, of Millhouses, Sheffield, have appointed Mr. B. Coathorpe as receiver and manager. He has taken possession of the property and assets of the company and is carrying on the business. The concern originally was under the control of the late Mr. W. S. Laycock, and in 1917 Charron, Limited, obtained a controlling interest. The chairman and governing director is Sir D. Dalziel, Bart.

New Companies.

Strick, Gorchs & Company, Limited. — Capital £100,000 in £10 shares, to carry on the business of coal, coke, oil and fuel merchants, contractors and agents, bunkering, steamship and commission agents, etc., and to adopt an agreement with Frank C. Strick & Company, Limited, and the Société Commerciale d'Affretements et de Commission. First directors: F. C. Strick, F. Gorchs-Chacou, Sir Arthur E. O'Neill, K.B.E., Gaston Bouffe, A. L. Thomson, and M. Marceron. Private.

Hampton Engineering Company, Limited.—Capital £30,000 in £1 shares, to take over the business formerly carried on by the Hampton Engineering Company (in liquidation) at Stroud; to adopt an agreement with J. Daniel and H. Daniel, and to carry on the business of general and mechanical engineers, founders, manufacturers of and dealers in pleasure and commercial motor vehicles or vessels, agricultural tractors, etc. The first directors are: J. Daniel, 31, Cathedral Road, Cardiff; M. Daniel, 31, Cathedral Road, Cardiff; and D. T. Jones, Hendre Newton, Porthcawl. Registered office: The Motor Works, Dudbridge, near Stroud.

V. Baynes Lucraft (Metals), Limited. — Capital £10,000 in £1 shares (2,500 7 per cent. cumulative preference). Registered offices: 21, Bartlett's Buildings, Holborn, W.C.

Globe Engineering Company, Limited, Brighouse.—Capital £5,000. Directors: Mr. R. M. Brooke, Mr. A. Dean, and Mr. A. M. Lawry.

British Tar Products, Limited, have been formed as a private company, with a capital of £400,000, to take over the undertaking of British Tar Products, Limited, and to adopt an agreement between the said old company and the Cavendish Syndicate, Limited. Directors: Mr. A. Woolley Hart, Mr. A. V. Derry, Mr. J. H. W. Laverick, Mr. T. Greensmith, Mr. M. Deacon, Mr. F. Woolley Hart, Mr. J. T. Todd, Mr. F. C. Swallow, Major A. J. Gainsford, and Mr. C. Agelo-Murray. The Yorkshire Coking & Chemical Company may appoint two directors, and the Tinsley Park Colliery Company may nominate one.

Obituary.

THE death is announced of Mr. J. F. Duff, Coatbridge, late cashier to the Scottish Iron and Steel Company, Phœnix and Victoria Iron Works.

MISS MARY MACARTHUR (Mrs. W. C. Anderson), who had for many years been a conspicuous leader in movements affecting the condition of women workers, died on Saturday at Golders Green. Miss MacArthur—in her public work she retained after her marriage to the late Mr. W. C. Anderson, M.P., the use of her maiden name, by which she was widely known—was only 40 years of age.

THE death took place on the 3rd inst. of Mr. John Smith, of Ryecroft, Heywood, aged 83 years. Mr. Smith was the senior member of the well-known firm of Messrs. Wm. Smith & Brothers, loom makers and machinists, Sun Ironworks, Heywood, which has been in existence since 1824. He had been intimately associated with the business all his life, and was well known in engineering circles in the North of England.

MR. JAMES H. HUTCHINSON, a prominent official of the Palmer Shipbuilding and Iron Company, died at his residence, 131, Osborne Road, Newcastle, on the 5th inst. Mr. Hutchinson, who was over 60 years of age, was appointed manager of the Hebburn shipyard in 1912. About four years ago, he was appointed chief adviser on all shipyard labour questions, and in that capacity he represented the firm on the various shipbuilding associations.

Personal.

MR. A. H. LEWIS, who has been for many years associated with Messrs. T. Beynon & Company, and the Ebbw Vale Company on the commercial side, has been appointed the Cardiff manager of Messrs. D. L. Flack & Son.

MR. JOHN WHITEHEAD WILSON DRYSDALE, of 3, Whittinghame Gardens, Kelvinside, Glasgow, lately managing director of Messrs. Drysdale & Company, Limited, engineers, Glasgow, died leaving personal estate in the United Kingdom valued at £41,725.

MR. H. STAFFORD RAYNER is terminating his connection with Sir W. G. Armstrong, Whitworth & Company, Limited (Manchester branch), where he has been for the last twenty years, as engineer and fuel expert. Mr. Rayner is shortly opening a consulting business in London.

AMONGST recent visitors to Tyneside is Mr. M. Clavering Coates, A.M.I.E.E., son of the late Mr. Wm. Coates, of Gateshead. Mr. Coates is managing director of Messrs. Coates & Company, of Melbourne and Sydney, well known engineers, who have carried out many important engineering projects in Australia and other parts of the colonies.

THE RIGHT. HON. EDWARD PRIAULX, first Baron Glenconner, 2nd Bt., chairman of the Union Bank of Scotland, Limited, of Charles Tennant, Sons & Company, Limited, of Tennant's Estates, Limited, and of Tharsis Sulphur and Copper Company, Limited, and of other companies, who died on November 21, left unsettled property of the gross value of £819,479, with net personalty, £640,899.

THE late Mr John Stubbs, O.B.E., of Faircroft, Solihull, Warwickshire, metal roller, managing director of the Hughes Stubbs Metal Company, a director of Elliott's Metal Company, Limited, of Messrs. Cooper and Goole, and of the Concordia Electric Wire Company, Limited, who died on November 1 last, left estate of the gross value of £36,760, with net personalty £29,151.

Gazette.

A PETITION for the winding up of the British Metallurgical Company (Birmingham), machinery manufacturers, will be heard at Walsall on January 13.

A PETITION for the winding up of the Gardiner Shipbuilding and Engineering Company, Limited, will be heard at the Royal Courts of Justice, Strand, on January 11.

A RESOLUTION was passed on December 13, and confirmed December 30, that Steel Stampings, Limited, should be voluntarily wound up, Mr. J. Ellison, C.A., 55, Newhall Street, Birmingham, being appointed liquidator. Meeting of creditors, 5, Waterloo Street, Birmingham, January 19.

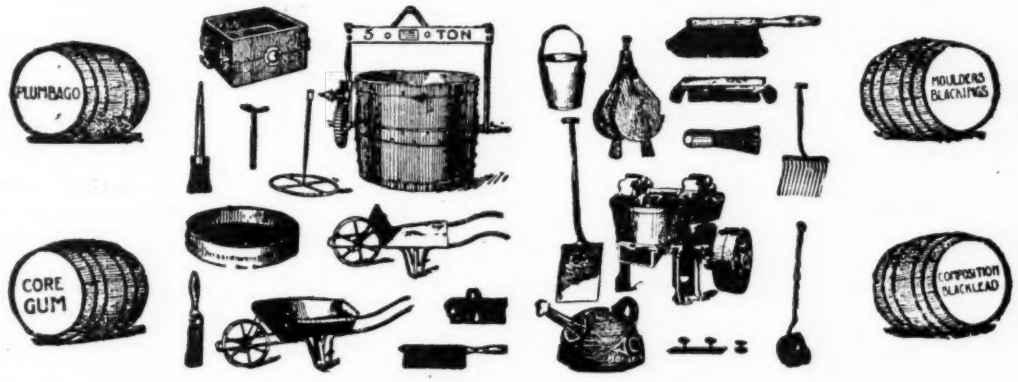
MESSRS. H. M. BIGGLESTON & SONS, The Foundry, High Street, Canterbury, ironfounders and engineers, and 22, St. George's Street, Canterbury, ironmongers, have dissolved partnership. December 31, 1918. Debts in connection with the business of ironfounders and engineers will be paid by H. Biggleston, who will continue to carry on the business on his own account in the name of H. M. Biggleston & Sons, while the ironmongery branch will be continued by Mr. F. R. Bigglestone as a separate concern.

Telephone: 21, Penistone. Telegrams: "Durrano, Penistone."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



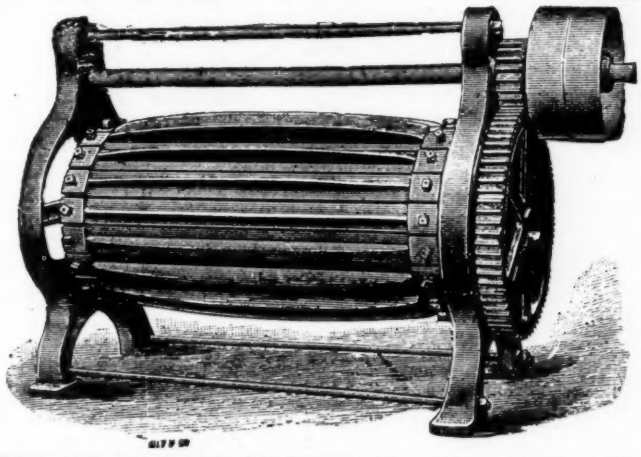
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully. THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	74	0	0
Three months.. ..	74	0	0
Electrolytic	81	10	0
Tough	81	0	0
Best selected	81	0	0
Sheets	130	0	0
India	130	0	0
Wire bars	83	0	0
Do. Jan.	83	0	0
Do. Feb.	83	0	0
Ingot bars	81	10	0
H.C. wire rods.. ..	92	0	0
Off. aver. cash, Dec.	75	16	8
Do. 3 mths., Dec..	76	3	4
Do. Settlement Dec.	75	15	2⅞
Do. Elec., Dec. ..	86	13	6⅝
Do. B.S., Dec. ..	84	13	4
Aver. spot, copper.. Dec.	75	14	10½
Do. Elec., Dec. ..	88	0	5⅛
S.D. tubes		17½d.	
Brazed tubes		17½d.	
Wire		16½d.	
Y.M. rods		10d.	
Do. 4x4 Sqs. ..		14d.	
Do. 4x3 Shts. ..		14d.	

BRASS.

S.D. tubes	15½d.
Brazed tubes	18½d.
Rods	14½d.
Shts. to 10 w.g. ..	13½d.
Wire	13⅜d.
Rolled metal ..	13½d.

TIN.

Standard cash ..	209	0	0
3 Months..	213	15	0
English	205	0	0
Bars	207	0	0
Chinese	203	10	0
Straits	225	0	0
Australian	216	0	0
Eastern	237	0	0
Banca	235	0	0
Off. aver., cash, Dec.	212	11	8
Do. 3 mths., Dec..	216	17	1½
Do. Sttlment., Dec.	212	10	5½
Aver. spot, Dec. ..	212	7	10½

SPELTER.

Ordinary	26	15	0
Remelted	21	10	0
Hard	20	10	0
Electro 99.9	36	10	0
English	29	10	0
India	24	0	0
Prime Western ..	28	10	0
Zinc dust	62	10	0
Zinc ashes	6	10	0
Off. aver., Dec. ..	28	11	6½
Aver., spot, Dec. ..	26	9	0

LEAD.

Soft forgn. ppt. ..	23	15	0
English	26	0	0
Off. aver., Dec. ..	24	11	10½
Aver. spot, Dec. ..	17	19	0

ZINC SHEETS.

Zinc sheets, spot ..	44	10	0
Do. V.M. ex. whf.	45	10	0
Do. ppt., f.o.b., N.Y.		—	
Do. c.i.f.		—	
Boiler plates	41	10	0
Battery plates ..	42	10	0

ANTIMONY.

Eng. regulus	45	0	0
Spec. brands	48	0	0
Chinese	33	0	0
Crude	24	0	0

QUICKSILVER.

Quicksilver.	12	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—			
45/50%	20	10	0
75%	30	10	0
Ferro-vanadium—			
35/40% ..	35/- lb. va.		
Ferro-molybdenum—			
70/80% ..	8/- lb. mo.		
Ferro-Titanium—			
23/25%, carbonless	1/6 lb.		
Ferro-phosphorus, 20/23%,	£49		
Ferro-tungsten—			
80/85%, carbon low	2/5 lb.		
Tungsten metal powder—			
98/99%	3/1 lb.		
Ferro-chrome—			
4/6% car.	£38		
6/8% car.	£37	10	
8/10% car. ..	£37	10	
Ferro-chrome—			
Max. 2% car. ..	£88		
Max. 1% car. ..	£106		
Max. 0.75% car. ..	£123		
65/75%, carbonless	3/- lb.		
Nickel—98/99%, cubes or pellets ..	£215		
Cobalt metal—97%,.	20/- lb.		
Aluminium—98/99%	£165		
Metallic Chromium—			
98/99%	7/6 lb.		
Ferro-manganese—			
76/80%, loose ..	£32		
76/80%, packed ..	£33		
76/80%, export ..	£43		
Metallic manganese—			
98/99%, carbonless	3/6 lb.		
Per ton unless otherwise stated.			

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	3	2
Finished bars, 18% tungsten	4	0
Per lb. delivered buyers' works.		
Extras—		
Rounds and squares 3 in. to 8 in. inclusive	4d. lb.	
Rounds and squares under ½ in. to ¼ in. ..	3d. lb.	
Flats under 1 in. by ⅜ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness	3d. lb.	
Bevels of approved sizes and sections ..	6d. lb.	
If in coils	3d. lb.	
Packing ..	4s. cwt.	
Bars cut to length 10% extra.		
Scrap from High-speed tool steel—		
Scrap pieces	5d.	
Turnings and swarf..	3d.	
Per lb. net, d/d steel makers' works.		

PIG-IRON.

N.-E. Coast—	
Foundry No. 1	225/-
Foundry No. 3 ..	215/-
Forge No. 4	212/6
Mottled	212/6
Hematite No. 1 ..	242/6
Hematite M/Nos. ..	240/-
Midlands—	
Staffs. common ..	225/-
,, part-mine forge	262/6
,, ,, foundry	267/6
,, Cold blast ..	385/-
,, basic	257/6
Northants forge ..	225/-
,, foundry No. 3	255/-
,, basic.. ..	250/-
Derbyshire forge ..	245/-
,, foundry No. 3	285/-
,, basic ..	295/-
Scotland—	
Foundry No. 1 ..	280/-
,, No. 3 ..	270/-
Hematite M/Nos. ..	285/-
Sheffield—	
Derby forge.. ..	250/-
,, foundry No. 3	270/-
,, basic	260/-
Lincs. forge	250/-
,, foundry No. 3	270/-
,, basic	250/-
E.C. hematite ..	250/-
W.C. hematite ..	290/-
All d/d in the district.	
Lancashire—	
Derby forge	240/-
,, foundry No. 3	275/-
Northants foundry No. 3	—
Cleveland foundry No. 3	242/6
Staffs. foundry No. 3	272/6
Lincs. forge	—
,, foundry No. 3	275/-
Summerlee foundry..	300/-
Glengarnock foundry	300/-
Gartsherrie foundry	300/-
Monkland foundry ..	300/-

FINISHED IRON & STEEL.

	£	s.	d.
Iron—			
Bars (crown) ..	27	10	0
Angles	28	0	0
Tees to 3 united ins.	28	10	0
Nut and bolt ..	26	0	0
Hoops	28	10	0
Marked bars (Staffs.) ..	33	10	0
Gas strip ..	32	10	0
Bolts and nuts, ¾ in. × 4 in.	57	10	0
Steel—			
Ship plates ..	24	10	0
Boiler plates ..	31	0	0
Checquer plates	30	0	0
Angles.. ..	24	0	0
Tees	25	0	0
Channels ..	25	15	0
Joists	24	0	0
Rounds, ⅝ in.– 3-in.	24	10	0
Rounds, 3 in.– 5½ in.	23	10	0
Flats, 5 in.–8 in.	25	0	0
Flats over 8 in.	24	10	0
Rails, heavy ..	25	0	0
Fishplates ..	30	0	0
Hoops	28	10	0
Black sheets, 24 g.	27	10	0
Galv. cor. sheets, 24 g.	28	10	0
Galv. fencing wire, 8 g. plain ..	42	10	0
Rivets, ¾ in. dia	42	0	0
Billets, soft ..	16	0	0
Billets, hard ..	17	0	0
Sheet and tin bars	17	0	0

PHOSPHOR BRONZE.

Rolled.	Per lb. s.	d.
½ in. to 1 in. wide ..	2	1½
1 in. to 1½ in. wide ..	2	0½
1½ in. to 2 in. wide ..	1	11½
Strips.	s.	d.
2 in. to 6 in. to 26 S.W.G.	1	10¾
6 in. to 12 in. to 26 S.W.G.	1	10¾
Sheets.	s.	d.
12 in. to 18 in. to 24 S.W.G.	1	11
18 in. to 24 in. to 24 S.W.G.	1	11¾
24 in. to 30 in. to 20 S.W.G.	2	0¾
30 in. to 36 in. to 16 S.W.G.	2	1¼
36 in. to 42 in. to 16 S.W.G.	2	2¼

Extras.

For Gauge: Any width up to 36 in. wide, ¼d. per lb. per thinner gauge.

Drawn Rods.	s.	d.
⅛ in. to ½ in. dia. in random lengths / ⅝ in. to 1½ in. dia. in random lengths	1	11½
Over 1½ in. to 1¾ in. ..	1	11½
Tubes—basis price ..	2	1¼

Delivery 2 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/3 to 1/9
Rolled—	
To 9 in. wide	1/10½ to 2/4½
To 12 in. wide	1/11 to 2/5
To 15 in. wide	2/- to 2/6
To 18 in. wide	2/1 to 2/7
To 21 in. wide	2/2 to 2/8
To 24 in. wide	2/3 to 2/9
Ingots for spoons and forks ..	1/3 to 1/9
Ingots rolled to spoon size ..	1/6 to 2/-
Wire round—	
3/0 to 10. G. ..	2/1 to 2/8

with extras according to gauge.

SWEDISH IRON.

F.O.B. Gothenburg net cash.

Bars, hammered basis sizes ..	Basis price.
Rolled Ordinary— Assortment ..	£ s. d. 33 0 0 to 40 0 0
Nail Rods— Square, round and flats ..	
Keg Steel / Faggot Steel	about £50 / Prices nominal.
Blooms—	
Single welded ..	£20 to £25
Billets—	
Single and double welded ..	£22 to £27
Pig-Iron—	
Grey, white or mottled ..	£15 to £20

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	34.79
No. 2 foundry Valley..	35.00
No. 2 foundry, Birm. ..	38.00
Basic	34.96
Bessemer	36.96
Malleable	36.96
Grey forge	35.96
Ferro-manganese, Atl. port	110.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	43.50
O.-h. billets	43.50
O.-h. sheet bars ..	47.00
Wire rods	57.00
	Cents.
Iron bars	3.50
Steel bars	2.35
Tank plates	2.65
Beams, etc.	2.45
Skelp, grooved steel ..	2.65
Skelp, sheared steel ..	2.65
Steel hoops	3.05
Sheets, black, No. 28 ..	4.35
Sheets, galv., No. 28 ..	5.70
Sheets, blue an'l'd, 9&10	3.55
Wire nails	3.25
Plain wire	3.25
Barbed wire, galv. ..	4.10
Tinplate, 100-lb. box ..	$7.00

COKE.

Welsh foundry	72/6
,, furnace	64/6
Durham & North. foundry	70/-
,, furnace	62/9
Other Districts, foundry	67/9
,, furnace	55/9